JOURNAL

JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

SAVOY PLACE LONDON W.C.2

TELEPHONE: TEMPLE BAR 7676 TELEGRAMS: VOLTAMPERE PHONE LONDON

VOLUME 2 (NEW SERIES) NUMBER EIGHTEEN JUNE 1956

PUBLISHED MONTHLY PRICE FIVE SHILLINGS

ANNUAL SUBSCRIPTION TWENTY-FIVE SHILLINGS

Contents

PAGE 319	ELECTRICAL INSTALLATIONS AND THE PROFESSIONAL ENGINEER
320	A DISCUSSION MEETING: THE STRENGTH OF INSTRUMENTS
322	POWER FROM THE CONON VALLEY
329	ADMINISTRATION AND THE ENGINEER *by* A. J. LITTON, B.E., B.SC., MEMBER
332	THE NEW RUGBY HIGH-FREQUENCY TRANSMITTING STATION *by* CAPT. C. F. BOOTH, O.B.E., MEMBER, and B. N. MACLARTY, O.B.E., MEMBER
338	A REVIEW OF THE *PROCEEDINGS*, PARTS A AND B
341	AN INFORMAL EVENING: ELECTRONICS AND AUTOMATION
343	THE ROLL OF HONORARY MEMBERS AND FARADAY MEDALLISTS
344	HOME EVENTS
346	NEWS FROM ABROAD
348	A RECOVERY CLAMP FOR RAISING UNDERWATER CABLES *by* J. PARKER
349	OBITUARY
352	CORRESPONDENCE
353	ANNUAL DINNER OF THE ADMIRALTY ELECTRICAL ENGINEERING OFFICERS
354	TECHNICAL PUBLICATIONS
356	MONOGRAPHS AND PAPERS PUBLISHED INDIVIDUALLY THIS MONTH
358	SOME RECENT BOOKS
360	LIBRARY ACCESSIONS
361	ANNOUNCEMENTS TO MEMBERS
363	ELECTIONS AND TRANSFERS
363	FORTHCOMING EVENTS
364	BRITISH NUCLEAR ENERGY CONFERENCE: FORTHCOMING PROGRAMME
364	CONTENTS OF THE CURRENT ISSUES OF THE *PROCEEDINGS*

The Institution is not, as a body, responsible for the opinions which are expressed in the *Journal*, unless it is stated that an article, letter or announcement officially represents the Council's views.

JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

VOLUME 2 (NEW SERIES) NUMBER 18 JUNE 1956

ELECTRICAL INSTALLATIONS AND THE PROFESSIONAL ENGINEER

THERE IS A TENDENCY, IN SOME QUARTERS, to assume that professional engineers are not required in any appreciable numbers for planning and carrying out electrical installation work and, conversely, that experience in such work is not necessarily sufficient to satisfy the requirements of Bye-law 12 when application is made for transfer from Graduate to Associate Member. In reality, the question, as with so many others, is one of degree.

The generally accepted definition of a professional engineer is 'one who by virtue of his general and technical education, practical training and subsequent experience, is fitted to undertake work requiring a high degree of personal responsibility in one or more of the branches of electrical engineering'. It might be added that two other qualities are necessary for success—flexibility of mind and soundness of judgment.

Apart from simple domestic installations and others of what might be called the single-distribution-board type, it is apparent that the work of the installation design engineer involves precisely those qualities of mind and training enumerated above. He has, in fact, to cover a very wide field. He must have a detailed knowledge of systems of wiring and systems of protection and he must be cognizant of a number of statutory and other requirements. He must be familiar with the properties and characteristics of a wide range of electrical apparatus and materials. He must be able to appreciate the activities which will be carried on in the projected building—office, school, factory, departmental store—and advise as to the best way electricity can aid those activities. He must be familiar with the construction of buildings—and to-day they are of many types—so that he can plan his installation to cover the building without interfering with its structural strength or its amenities. He must take an intelligent interest in tariffs, since they may well affect the layout of the installation, he must consider the effect of the public supply on switchgear capacity, he must arrange his intakes to best advantage and may even have to make provision for one or more substations.

At every stage he is the electrical adviser to the building owner and the architect or builder. He must arrange the progress of his work so that each part of it is carried out at the appropriate time-stage of the building contract. Moreover he must be conversant with the economics of the work so that he can estimate beforehand and with precision what it will cost a function which his architectural colleague leaves to the quantity surveyor.

It may be true that the planning of even the larger installations can normally be done without recourse to higher mathematics. Nevertheless each job presents a separate and different problem requiring its own solution and the engineer is compelled to choose, from his training and experience, the methods he will use to satisfy the requirements of each particular case. Many of those who have had more than average opportunity of comparing it with the work in other branches of engineering would maintain that the professional content of the work of the installation engineer is high.

The successful planning of a wide range of electrical installations requires the skill of the professional engineer. This is shown by the fact that not only Corporate Members but Associates are engaged in the industry, all doing the job admirably, though the latter do not fall into the category of Chartered Electrical Engineer. It would be unfortunate if a feeling that there was any lack of recognition were allowed to grow or persist, as this might discourage young men in the installation industry from making the effort to get professional recognition. It would also lessen the prestige of the installation industry, and thus deflect promising young men away from it, with consequent adverse effects for the whole of the electricity industry, the strength and wealth of which spring from the use which consumers can make of electricity in the installations provided for them. It is the purpose of this note to emphasize the real position.

The Institution has from the first been aware of the importance of the installation side and, as is well known, set up the first Wiring Rules Committee in 1882. They certainly had no doubt of the importance of the work they were initiating, for they were a very high-level committee indeed, more than half the members being of Presidential standing. Since then many new branches of electrical engineering have sprung up and taken their share of the interest. This notwithstanding, the importance of installation work and its professional nature are reaffirmed, for these aspects have certainly not receded through the widespread developments of electrical science and engineering. The Council's endeavour is to make a true appraisal and to correct misapprehensions.

A Discussion Meeting

THE STRENGTH OF INSTRUMENTS

A Measurement and Control Section discussion on the design of electrical measuring instruments for arduous conditions of service, which was opened by Mr. C. A. Oldham and Mr. G. N. Harding, was held at Savoy Place on the 31st January, 1956.

Opening Dissertations

MR. OLDHAM said that he proposed to confine his opening remarks to the design aspects of instruments intended to meet high durability requirements and severe climatic conditions.

Durability requirements are usually considered under the headings of vibration, shock and acceleration.

The designer's first approach to the problem of mechanical disturbance is usually one which in any event constitutes good basic design. The more pronounced problems are, of course, associated with the moving elements. In loose terms, the strength/mass ratio must be kept as high as possible, which usually follows a reduction in mass, this being in itself desirable. Here, physical form and choice of materials are of great importance. Except comparatively rarely, when dynamic considerations require otherwise, moments, and moments of inertia, about an axis of rotation must be kept to a minimum. The entire moving system of a small permanent-magnet moving-coil instrument may weigh no more than 200 mg.

Design along the above lines, however, is often circumscribed by other functional requirements, and to-day's demands are such that the mechanical disturbances cannot be withstood by careful design of the instrument mechanism alone. Recourse has to be made to other methods. For example, the interposition of small amounts of semi-hard rubber in the mounting arrangements between the instrument proper and the case can render the former immune to the effects of severe shocks or high impulsive accelerations, which would cause a normal instrument to disintegrate. Such means, however, do nothing to absorb the sustained vibrations involving relatively low accelerations and frequencies, or to mitigate the consequent bad performance, wear and fatigue, but these may be overcome by the use of resilient shock absorbers, interposed between the case and the structure upon which the instrument is to be mounted, or between the mounting panel and the main structure.

The design of these mounts is a specialist matter involving considerations of the mass of the body to be supported, the relative positions of the centre of gravity and the mounts, and the frequency and amplitude of the vibrations to be absorbed. Who should be responsible for determining where these resilient mounts should be introduced and for their design or selection?

The functional effects of linear acceleration may be significant at 1–2*g* or less. Theoretically, if the instrument is statically balanced there should be no deflectional effect. In practice, the effects involve the relationship of control torques, mass and its distribution, and other considerations.

The effects of angular acceleration, while rarely permanent, can cause serious functional derangement in the way of false indications, swinging pointers, and false operation of sensitive moving-coil relays, etc. These effects cannot be balanced out mechanically. It is possible in certain circumstances to modify these effects by regeneration or feedback where there is in the system an element in addition to the indicator which is responsive to the same angular acceleration, or to a derivative of it, but, in general, this is not practicable. The usual remedy is appropriate relationship of control torques and moment of inertia. Damping is usually neglected in designing to limit the effects of angular acceleration. Unless very large and therefore liable to affect response characteristics adversely, its effect is negligible.

With instruments for use under extreme climatic conditions temperature presents perhaps the most difficult problems. The selection of materials, their protection and their proximity (in terms of electrolytic action), must be carefully considered, particularly in the unsealed instrument.

Fogging is often a problem. Should an unsealed instrument have its leakage paths reduced to a minimum, or should it be freely ventilated? Are non-metallic cases, e.g. phenolic resin, capable of affording long-term effective sealing to modern standards? Are rubber gaskets—often used with such cases—capable of withstanding the extremes of temperature? Is it considered that sealing to meet present-day requirements implies a metal-glass-ceramic technique? The extremes of temperature to be withstood add to the difficulties of the metal-glass-ceramic technique. The imperfect equating of linear temperature coefficients has to be offset by a bond strength which will withstand the disruptive stresses at extremes of temperature even under shock conditions.

It is contended by some that hermetically sealed instruments should be standardized for all purposes, even though many may be used under conditions where the commercial standard instrument would give adequate service. This is at least controversial. The hermetically sealed instrument will cost more and is more difficult to service; and in certain circumstances the development of a fault may render it a greater liability than an unsealed instrument.

Mr. G. N. Harding remarked that electrical indicating instruments, particularly ammeters and voltmeters, are used in extremely wide conditions. They may well be expected to operate while being subjected to high- or low-frequency vibrations, and to shocks of up to 40*g*.

Such conditions are often combined with extremes of temperature and, sometimes, high humidity.

Before or while being subjected to such conditions the instruments may have suffered total immersion in water, attack by fungus, insects, or salt-water spray. When in use they may be mounted with the dial in either a vertical or a horizontal plane, and sloping, facing up or facing down. When fitted to aircraft they will be subject to accelerational loading, and on both aircraft and small sea-going vessels, to angular acceleration due to rolling of the craft. In many miniaturized equipments there will be a considerable temperature differential, amounting to possibly 30° C or more, between the atmosphere at the front of the instrument and that surrounding the case of the instrument. In addition, there may be considerable pressure changes to be withstood, not only by airborne instruments but also by instruments for ground equipment.

In both national and Service specifications evaluation of the performance that may be expected from instruments subjected to these conditions is often achieved by accelerated tests. For example, the highest relative humidity and the highest ambient temperature are combined in the accelerated damp-heat test. Furthermore, hot humid conditions are experienced continuously for 84 days in the tropical-exposure test, this being approximately equivalent to three years' service under jungle conditions.

The vibration met over most of the frequency range is usually circular. Such circular vibration is particularly important in relation to indicating instruments, for it causes the pointer to creep over the dial, producing a steady but incorrect indication. In one instrument this creep amounted to approximately 75% of full-scale deflection.

The mounting angle and position relative to the observer make viewing at considerable angles to the perpendicular relatively common; hence the use of platform scales is desirable and the reduction of tunnel effect is essential. Good initial accuracy is required, in order that, on replacement of a faulty instrument by a fresh one, the reading on the dial shall remain sensibly constant for the same operating conditions of the equipment. Experience with a variety of instruments used on many different equipments in all parts of the world has demonstrated that the only satisfactory method of meeting the climatic conditions is by enclosing the mechanism within a sealed case.

General Discussion

The ensuing discussion was sustained by twelve speakers and revealed some preference for resilient mounting of panels rather than of instruments when space permits this external treatment, and a recognition of the value of shock absorption by internal design when instruments are cramped and hence solidly mounted, as in aircraft, or are likely to be abused in transit. Instances were given of designs using taut suspension and also of a sprung-pivot system. A combination of internal and external treatment was favoured and several speakers thought that consultation between maker and user, to decide how best to provide the service in particular instruments, is preferable to the employment of a severe specification, which might become habitual. A speaker stated that official specifications for instruments for use in aircraft are based upon flying surveys in a very large number of aircraft.

It was noted that in stipulating figures for g, time values are also relevant, and that resonance problems may be met by making the natural frequencies of the instruments different from those prevailing in the installation and as high as consistent with acceptable damping. A speaker observed that pivots, which may be only 2 mils in radius, will wear away under transient vibrations transmitted through resilient mounts. This may be accepted in aircraft intended for only 1 000 hours' service but not in other installations. A related instance of the accidental derangement of solidly mounted relays in power stations by impact rather than vibration was cited, and various speakers remarked on the speed and manoeuvrability of modern aircraft, the high rotational accelerations caused, and the pilot's reliance on instruments. Someone questioned the ability of recording, as against indicating, instruments to withstand bumping experimental flights: the alternatives of recording by a rugged meter movement fed through an amplifier, and by a servo telemeter, were suggested.

Some difficulty was expected in finding materials to withstand the proposed 100° C tests, especially in sealed instruments. It was also noted that if the specified leakage rate for sealed instruments remains unrelated to their size, a meter of 50 cm^3 volume which at present could change its air once a year might do so more frequently if it could be made smaller. Leak testing by means of nitrous oxide under pressure and the easy detection of the gas attracted interest. In discussing production methods of sealing for rough service at −20° C, a speaker recounted the partial failure of all but metal-glass techniques: however, there was some support for the use of suitable rubber seals, even under heat cycling, provided the degree of compression during assembly was restricted to about one-third by appropriate rebating, and the possible use of silicone rubbers was mentioned. Attention was drawn to the value of a zone of flexible metal in accommodating temperature stresses in a large glass vessel solder-sealed to a metal case, to the phenomenon of diffusion through die-castings, and the need to allow for evolution of moisture from materials.

There was a suggestion that desiccators in instruments might solve many problems; a subsequent speaker said that under severe vibration these powders are difficult to confine. Many, but not all, speakers deprecated zero adjusters, especially in sealed instruments. The operational need to repair sealed instruments was upheld, although there were several suggestions that they might be classed as expendable or be returned complete to the makers for repair.

POWER FROM THE CONON VALLEY

On the 5th January this year, the General Manager of the North of Scotland Hydro-Electric Board, Mr. A. A. Fulton, read a paper before The Institution entitled 'Highland Water Power—The Developments of the North of Scotland Hydro-Electric Board'. This paper was written by his predecessor, Mr. T. Lawrie, who unfortunately died in August, 1955. Since the paper is itself a very readable survey of its subject, a short review of it is not being included in the Journal. It is published in this month's issue of the Proceedings, together with a report of the discussion on the 5th January. Those who are interested in the subject and who do not take Part A of the Proceedings would do well to obtain a reprint of the paper (No. 1909 S). Instead of a short review, there appears here an article on one example of the Hydro-Electric Board's work—the scheme for developing the water-power resources of the Conon Valley, which lies north-west of Inverness. This has been written by one of the Board's engineers and gives, inter alia, *information about recent progress on the installations, which many of those who took part in The Institution's Summer Meeting last year will recall with interest and pleasure.*

General Features

THE catchment area of the River Conon is about 460 sq. miles and stretches from the high mountains (some of which are over 3 500 ft) of Wester Ross to the shores of the Cromarty Firth. It is essentially a high level plateau drained by the river and its numerous tributaries, principally the Meig, the Bran, the Black Water and the Orrin. The average annual rainfall varies from 120 inches on the mountains in the west and north to 30 inches near the east coast. Possessing such obvious advantages for water-power development, the Conon Valley has for a long time attracted the notice of hydro-electric engineers and promoters. In 1921 the Water Power Resources Committee included this area in their report on possible hydro-electric developments. At that time it was proposed to divert the waters of Loch Fannich to a power station near Loch Broom on the west coast.

That scheme came to nothing, but in 1926 the Rossshire Electric Supply Co. built as a first development a small station of 1 000 kW capacity to utilize the 120-ft fall at the Falls of Conon. The intake was at a low weir at the outlet of Loch Luichart. During the first year the output was only 200 000 kWh but by the time the station was superseded in 1950 it was producing nearly 14 million kWh a year, for in the meantime the plant and pipe-lines had been progressively increased in capacity to 2 750 kW.

When, under the Act that established them, the North of Scotland Hydro-Electric Board came to develop the area they promoted the following three schemes:

(i) THE FANNICH SCHEME. This was approved by Parliament in 1945 and was chosen because it enabled a quick start to be made to construction.

(ii) THE GLASCARNOCH—LUICHART—TORR-ACHILTY SCHEME. This is a much more comprehensive scheme and covered most of the area. It was approved by Parliament in 1947.

(iii) THE ORRIN SCHEME. This deals with the River Orrin only and was approved in 1955.

The map in Fig. 1 shows the six power stations of the three schemes. Their total installed capacity is 107 400 kW with an estimated average annual output of 438 million kWh, made up as shown in the table at the end of the article. The average annual load factor of the group is therefore about 47%. This is a higher load factor than most of the Board's other hydro-electric schemes and is made possible by having available a total water storage of 170 million kWh (39% of the annual output) in the principal reservoirs.

At present, the Grudie Bridge, Luichart and Torr Achilty power stations have been completed, although the full annual output at Luichart and Torr Achilty will not be available until the Glascarnoch section and the diversion works are finished. The Glascarnoch power station is expected to be commissioned in 1957 and Orrin power station in 1960, by which date all the diversions should also be completed.

As shown on the map in Fig. 1, diversion aqueducts are being provided to bring water from the head waters of the River Carron and of the River Broom in the north and from tributaries of Loch Maree in the west. The total catchment area utilized will thus be increased from 311 to 345 sq. miles, on which the average annual rainfall is estimated at 75 inches. The diversions are particularly valuable since they are from elevated areas with high rainfall; for example, one square mile of the River Carron catchment area at Glen Beag in the north is equivalent to 35 sq. miles of catchment area at the level of Torr Achilty.

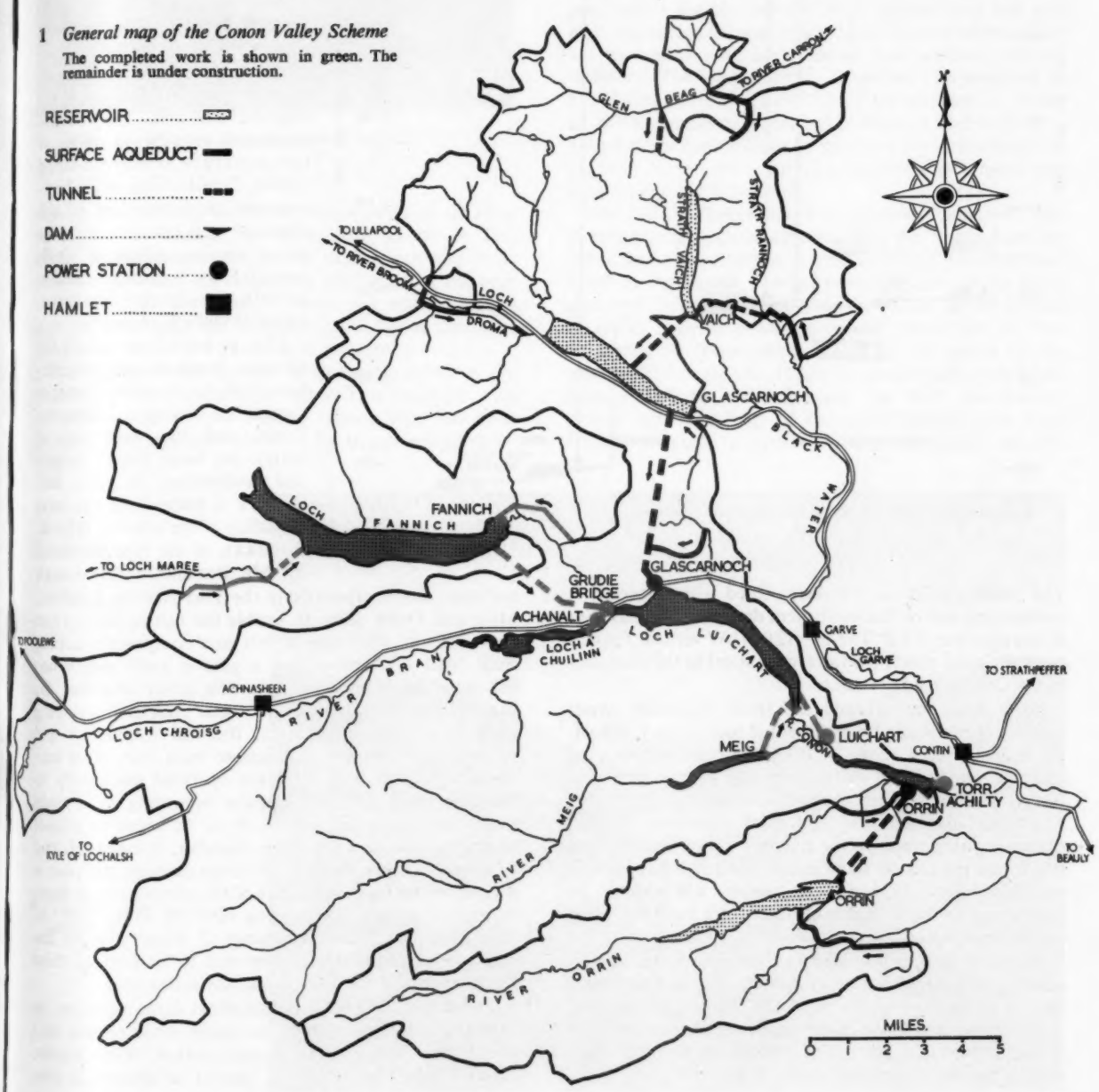
The Grudie Bridge power station of the Fannich Scheme has been in operation since 1950. It is supplied with water through a concrete-lined low-pressure tunnel which is 3½ miles long and a high-pressure steel pipe-line of 8 ft diameter. The most interesting feature of the scheme is that storage was obtained by taking advantage of the depth of Loch Fannich by the construction of an underwater intake 80 ft below the level of the loch. The construction of this intake was difficult because it involved careful and accurate driving of the tunnel under the bed of the loch until the thickness of the rock between the tunnel face and the water was no more than 15 ft. The remaining rock was then removed by an underwater explosion produced by a carefully designed pattern of

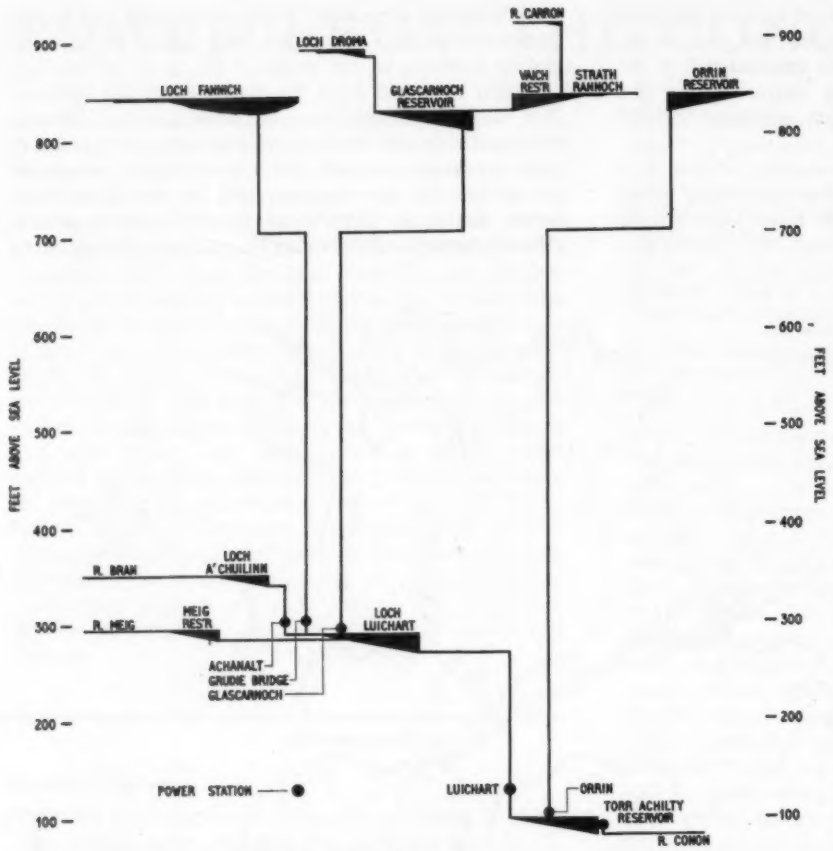
charges amounting to three-quarters of a ton of gelignite in 102 holes. This tricky operation was completely successful and no trouble has been experienced at the intake. The storage is now being augmented by the construction of a rock-fill dam which will raise the level of Loch Fannich by 19 ft.

The Glascarnoch–Luichart–Torr-Achilty Scheme is a three-stage development. The Glascarnoch stage, which is the highest, is centred on the large Glascarnoch storage reservoir with a spillway level 826 ft above sea-level. The dam is presently being constructed and is of a composite nature, the centre part being of concrete gravity section and the wings of fill. It is 1 670 ft long and 92 ft in height from the river bed to the spillway. The water collected from Glen Beag, Loch Droma, Strathrannoch and Strathvaich is fed into it by means of open aqueducts, tunnels and two collection reservoirs. As at Fannich, the water required for the Glascarnoch power station is taken from the reservoir by a low-pressure tunnel and thereafter by a surface steel pipe-line.

1 *General map of the Conon Valley Scheme*

The completed work is shown in green. The remainder is under construction.





2 *Diagrammatic section of the Conon Valley Scheme*

The tunnel, which is now being lined with concrete, is 6 miles long and of 10 ft equivalent diameter; the diameter of the pipe-line is 8 ft. The two 12 000 kW vertical Francis turbines in the power station are identical to the machines in the Grudie Bridge station.

Both these stations and the small Achanalt power station on the River Bran discharge into Loch Luichart. Its level has been raised 40 ft by the construction of a concrete gravity dam 680 ft long and 45 ft high at the outlet. This dam, with a concrete-lined tunnel of 16 ft equivalent diameter and two steel pipe-lines of 11 ft diameter, takes water to the Luichart power station, and this forms the second stage in the scheme. It has been in operation since 1954 and its output will shortly be augmented by the diversion of water from the River Meig on the completion of a dam there.

The third stage is provided by the lowest power station of the group, which is at Torr Achilty. Its main interest is that it is built integrally with the 50 ft-high dam and regulates the flow in the lower reaches of the River Conon through two adjustable blade propeller turbines. The station has been operating since 1954.

Constructional work was started last year on the Orrin Scheme, which is a straightforward high-head development, the reservoir having a spillway level 840 ft above sea-level and the tail-race discharging into Torr Achilty reservoir, which has a spillway level 100 ft above sea-level. The main dam is to be of concrete gravity section, 1 040 ft long and 135 ft high, while a smaller subsidiary dam close to it is to be of fill construction. Two diversion aqueducts will increase the flow to the reservoir and make the effective catchment area 54 sq. miles. A low-pressure concrete-lined tunnel, 3¼ miles long, and a high-pressure steel pipe-line of 6 ft diameter will take water to the power station, where a single vertical Francis turbine, rated at 25 000 h.p., will drive an alternator of 18 000 kW capacity.

The promotion of these schemes involved long negotiations with the statutory Fisheries Committee (set up to advise the Board and the Secretary of State), the local fishery boards and landowners. A great deal of work is being done to ensure the safety of the stock of salmon. Fishlocks, of the type pioneered by Mr. Borland, a Kilmarnock engineer, are incorporated in the Torr Achilty, Luichart, Meig and Orrin dams to enable the fish to pass up and down stream. This type of fish pass comprises a sloping shaft with a chamber and a gate at each end. When fish have been attracted into the lower chamber the gate there is closed and as the water rises in the sloping shaft to the upper chamber, the fish follow up and on reaching the upper chamber pass out of it into the loch beyond. The gates are operated electrically so that the shaft fills and empties according to a cycle which best suits the fish. A flow, sufficient to attract ascending fish into the lower chamber, is essential, and to obtain this the regular discharge through the pass is supplemented by passing part of the compensation water through a turbine discharging near the lower gate. At the Orrin dam, where the range of water levels in the reservoir is about 100 ft, there are to be four of these fishlocks so that fish can pass at any water level.

The safe descent of young smolts at dams is ensured by careful siting of the fishlock or special smolt pass in relation to the power-station tunnel intakes. When smolts, owing to the high pressures, cannot be allowed to pass

3 *Turbine room at Grudie Bridge power station*

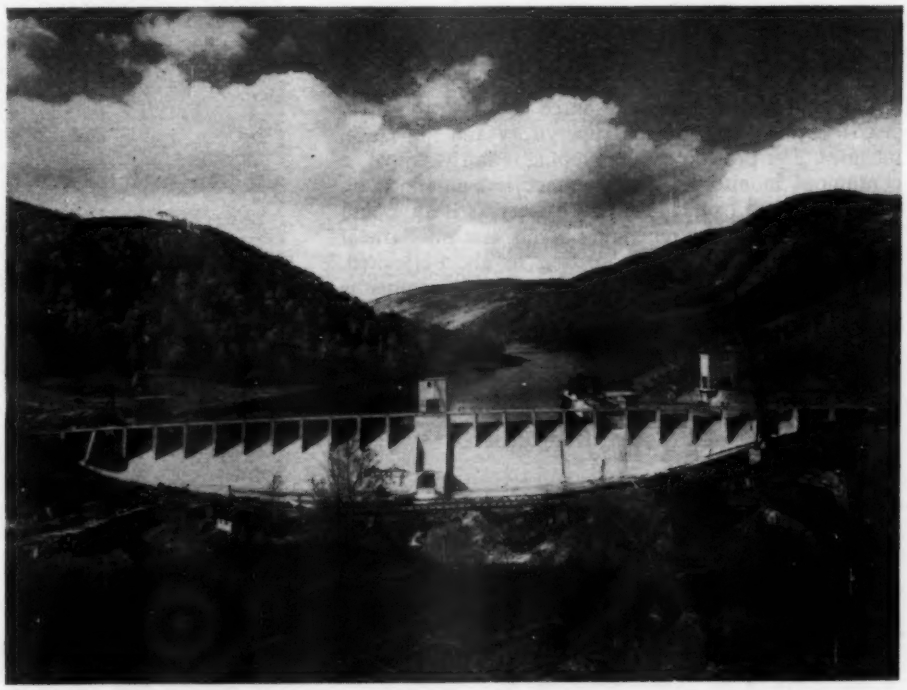
through the turbines, the main intakes must be screened off during the season for descending smolts by fine screens with apertures not greater than 1 inch × ½ inch; also, to ensure that the smolts are not forced by pressure on the face of the smolt screens, the water velocity through them must not exceed 1 ft/sec. These measures add greatly to the size and cost of the intake works.

To compensate for the loss of spawning gravel by the creation of the Glascarnoch reservoir, a hatchery with accommodation for two million salmon eggs has been provided. The eggs are obtained by trapping and stripping fish at a fish stop constructed on the river some distance below the dam. The eggs hatch out usually in March each year, and thereafter the fry are distributed to suitable feeding grounds in the rivers and tributary burns of the Conon basin.

Electrical Connections and Transmission of Output

The generating voltage at all the stations in the Conon Valley is 11 kV. At Grudie Bridge, Glascarnoch and Luichart the machines feed onto 11 kV 500 MVA switchgear and a double-circuit 132 kV transmission line collects the output through 11 kV/132 kV transformers which are connected onto each line at each station through isolators. The output from Orrin will be switched at 11 kV through one 11 kV/132 kV transformer to either of the transmission lines, again through isolators. The Torr Achilty station feeds by means of two unit-connected 11/33 kV transformers through 750 MVA switchgear into the existing 33 kV network.

The 132 kV double-circuit transmission line feeds into Beauly substation and, together with the output from the Affric and Shin schemes, is transmitted to Aberdeen and Keith on the east. A double-circuit line, one circuit being teed and the other ringed into Fasnakyle power station *en route*, runs to a further 132 kV substation at Fort Augustus, so transmitting energy to the south of the system. At Beauly two 15 MVA transformers step down from 132 kV to 33 kV, feeding the 33 kV distribution system with the help of the contribution from Torr Achilty referred to earlier. This arrangement has the



4 *Luichart dam, nearing completion*

5 *Luichart power station*

merit of requiring smaller 132 kV/33 kV transformers than would otherwise be necessary.

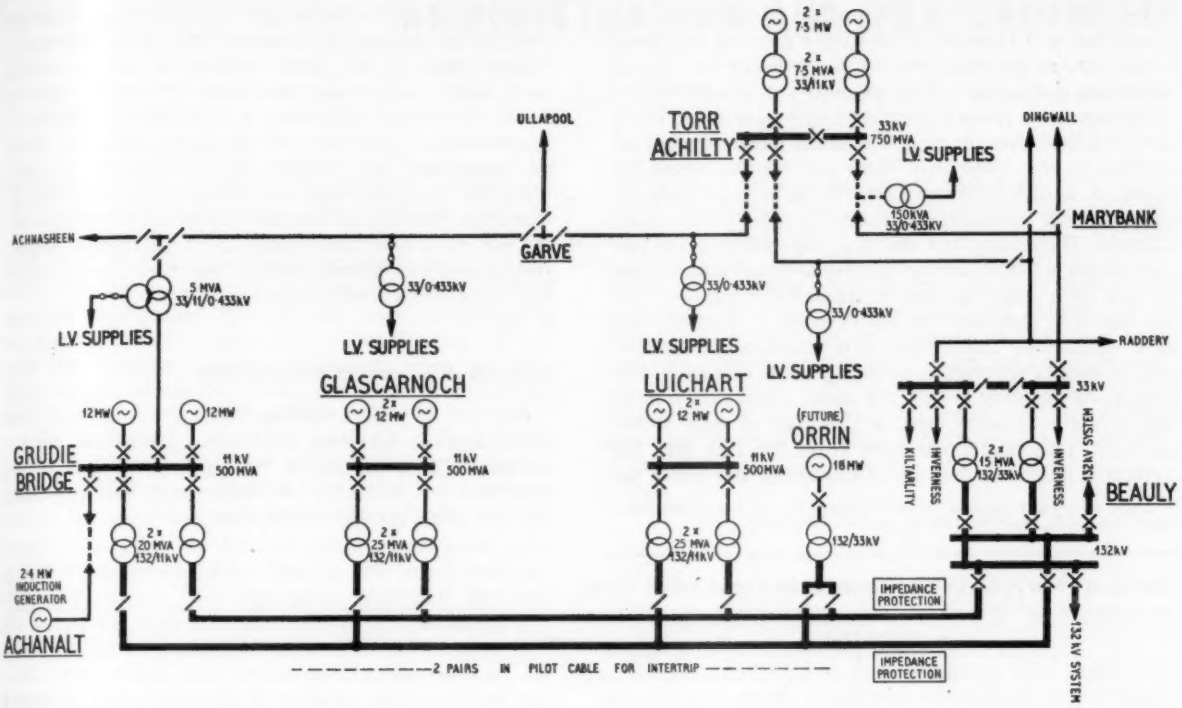
Protection on the Conon Valley double-circuit line is by means of a high-speed impedance scheme, in which the first stage covers the transmission line and a major portion of the transformer high-voltage windings. The protective scheme includes two intertripping circuits between the five stations, Grudie Bridge, Glascarnoch, Luichart, Orrin and Beauly, being provided over a pilot cable along the valley. This scheme covers transformer faults, and is considerably cheaper (approximately half the capital cost) than the alternative arrangement using separate 132 kV switches for each line at each tee-off point.

The pilot-cable services are shared between protective-gear functions and control, supervisory and indication facilities. The protective intertripping is fairly simple; a continuous monitoring direct voltage is maintained on the pilot cables from a 240-volt battery at Beauly, and monitor relays at the remaining points give an alarm if the pilot cables should be broken or short-circuited. Intertripping can be initiated at any of the five points by removing the monitoring supply and imposing a voltage in the reverse direction. This intertrips all the five ends. The tripping supply at Beauly is on 110 volts, and 240 volts elsewhere. The continuous total monitoring current is of the order of 50 mA and the tripping is accomplished in approximately 150 millisec.

Control and Communication

The Group Control Centre is in Torr Achilty power station and is in direct telephone contact with the central System Control Centre at Pitlochry. Instructions to the individual power stations in the group are given from the control room by telephone. The output of the machines at each station, together with the loading on the transformers stepping up to the 132 kV transmission line, are displayed in the control room at Torr Achilty. The telephone communication and meter indications are transmitted over the multi-pair aerial cable which is used

6 *Turbine room at Luichart power station*



7 *Schematic of transmission system in the Conon Valley*

for protection and which connects the power stations to each other and to the Beauly switching station.

In the Torr Achilty power station control room the control desk has a central writing panel, a telephone switchboard and a main instrument panel, comprising generator instruments and an alarm facia. Two wings complete the control desk, and these are subdivided into panels, one for each of the five power stations. The Torr Achilty station control panel provides complete control for two machines, together with the 33 kV line switches. The remote-station panels are arranged to show the individual loading on each machine and transformer in each power station.

Communication between Group Control in Torr Achilty power station and System Control at Pitlochry is over the pilot cable to Beauly substation, where it is extended by means of power-line carrier-telephone equipment on the 132 kV circuits to Errochty substation, and hence by a 12-channel carrier-on-cable system to the System Control at Port-na-Craig House, Pitlochry. The control engineer at Torr Achilty has a complete picture of the state of the stations under his control at all times, and telephone communication with them and with the System Control engineers at Port-na-Craig, 90 miles away.

The pilot cable mentioned above extends from Beauly substation to Grudie Bridge power station by way of the intermediate power stations at Torr Achilty and Luichart. It comprises two heavy pairs for intertripping and lighter pairs for telephony, indications and controls. The section between Beauly and Torr Achilty is suspended on the 33 kV H-type wood-pole line. Beyond Torr Achilty the cable is routed partly overhead and partly underground to Contin village, where a spur section runs off to Luichart power station. The main cable to Grudie Bridge power station is supported on the Post Office pole line along the Garve–Achnasheen road.

The cable has been made up in quad formation, using 1/·036 copper conductors. The telephone and control circuits use single conductors, but for the intertrip circuits, since the d.c. resistance of the cable must be kept low, four wires, i.e. one quad, are connected in parallel to form one conductor for each of the two pairs. Thus the cable is made up of 14 pairs (Torr-Achilty–Beauly, Contin–Luichart and Glascarnoch–Grudie-Bridge), 26 pairs (Torr Achilty to Contin), and 20 pairs (Contin–Glascarnoch). It is exposed to induction from the two 132 kV circuits which parallel it throughout its length, and it has been necessary, therefore, to have good insulation. The completed cable has been tested and has withstood 5 kV d.c. between conductors and 15 kV d.c between all conductors and sheath for five minutes in each test, which allows considerable margin with any expected voltage.

The system of telemetering used from the power stations to Torr Achilty employs electronic technique throughout. The principles have been described by

Dunn and Chambers,* but briefly it comprises the transmission of impulses taken from a rotating watt-hour meter, and at the receiving end determining the rate of impulsing and turning this rate into a meter deflection. Each impulse is given a teleprinter character code, which is transmitted over the voice-frequency telegraph channel applied to one quad in a cable per station. Since the speed of signalling is rapid (50 bauds) it is possible for several meter indications to share the same transmission channel. The coding and decoding equipment comprises cold-cathode tubes, and an electronic distributor is used to give each meter its turn to transmit an impulse over the channel. There are few relays in the equipment, and it is confidently anticipated that maintenance thereby will be greatly reduced. A further great advantage of this system of metering is that the meter indication follows the primary quantity with a time lag of only a few seconds. This comes naturally from the fact that the system is based on the rate of impulsing and hence the reception of each impulse provides the opportunity to carry out any necessary correction in the meter indication.

From each of the power stations to the associated dams, other pilot cables have been provided and over these, water-level indication is transmitted, telephone communication provided and an alarm indication from the generating sets worked by compensation water. With the Meig dam and the Glascarnoch head works, where the Post Office have already provided circuits for the use of contractors during the construction stages, arrangements have been made to use these circuits rather than lay expensive pilot cables.

* Dunn, R. H., and Chambers, C. H.: 'Telemetering for System Operation', *Proceedings I.E.E.*, Paper No. 1400 M, July 1952 (100, Part I, p. 39).

Operating Experience at Grudie Bridge

For the five years during which the Grudie Bridge power station has been operating, an analysis of the output, after allowance has been made for the diversion aqueducts not being fully complete until 1955, indicates that it is slightly greater than estimated.

Details of Plant in the Power Stations of the Conon Valley Group

	GRUDIE BRIDGE (FANNICH)	GLASCARNOCH	LUICHART	TORR ACHILTY	ACHANALT	ORRIN
Gross static head, ft ..	537	529	185	52	65	732
Number and capacity of sets	2 × 12000 kW	2 × 12000 kW	2 × 12000 kW	2 × 7500 kW	1 × 2400 kW	1 × 18000 kW
Average annual output, kWh	82 × 10^6	112 × 10^6	124 × 10^6	36 × 10^6	8 × 10^6	76 × 10^6
Type of generator ..	Synchronous	Synchronous	Synchronous	Synchronous	Asynchronous	Synchronous
Speed, r.p.m.	500	500	250	167	336	600
Generator cooling ..	Water Closed circuit Air	Open circuit Air	Water Closed circuit Air	Water Closed circuit Air	Open circuit Air	Water Closed circuit Air
Type of turbine	Vertical Francis	Vertical Francis	Vertical Francis	Vertical adjustable blade propeller	Vertical adjustable blade propeller	Vertical Francis
Runner	Stainless steel	Stainless steel	Steel	Stainless steel	Steel, with stainless-steel protection	Stainless steel
Type of main inlet valve	Butterfly	Butterfly	Butterfly	Intake gate isolation	Intake gate isolation	Rotary plug valve
Type of spiral casing ..	Welded steel	Welded steel	Welded steel	Concrete	Welded steel	Welded steel
Auxiliary supplies ..	Unit auxiliary transformer	Unit auxiliary transformer	Unit auxiliary transformer	Unit auxiliary transformer	415-volt cable from Grudie Bridge	Unit auxiliary transformer
Voltage regulator ..	Normally inactive vibrating contact	Normally inactive vibrating contact	Normally inactive vibrating contact	Normally inactive vibrating contact	—	Static high speed
Details of switchgear ..	11 kV 500 MVA	11 kV 500 MVA	11 kV 500 MVA	33 kV 750 MVA	11 kV 500 MVA	11 kV 500 MVA
Details of main transformer	11/132 kV 20 MVA OFW‡	11/132 kV 25 MVA ON/OB‡	11/132 kV 25 MVA ON/OB‡	11/33 kV 7·5 MVA ON‡	—	11/132 kV 20 MVA ON‡

‡ OFW: oil-immersed forced-oil circulation with water cooling. ON/OB: oil-immersed natural cooling with alternative additional air-blast cooling. ON: oil-immersed natural cooling.

ADMINISTRATION AND THE ENGINEER

A. J. LITTON, B.E., B.Sc., MEMBER

This century has seen the rise of engineering to unprecedented importance, and it is natural both that engineers themselves should desire more influence in the direction of their work, and that technical qualifications should become increasingly necessary for entry to managerial positions. This article points to the broad outlook that is demanded of the aspiring engineer-administrator, and describes some newer concepts of industrial organization—concepts which are well illustrated by an account of the famous Hawthorne experiments. The article is an extract from the Chairman's Address to the Irish Oversea Branch, delivered by the author on the 20th October, 1955, at Dublin.

In spite of the fact that the engineer occupies an eminent position among all those who have built up and who still elaborate the modern world, it must be admitted that the place allotted to him in the organization of society is inadequate and that he rarely attains to positions of command. Though ever ready to collaborate in carrying out the projects of others, he can seldom have the direction of those economic, administrative, and political forces on which the progress of public institutions and industry depends.

That this should be so is, in my opinion, largely due to the neglect by engineers of the art and science of administration. This neglect may spring from a tendency among engineers to specialize more and more, and to measure progress by the yardstick of scientific and industrial equipment rather than by the overall development of mankind. Thus they fail to appreciate the need for a general and scientific culture so necessary for success in the administrative field.

In recent times new trends of thought seem to be emerging, more especially in America, and engineers are awakening to the need for study in order to enter the field of administration. These trends must indeed be welcomed since we are now living in the age not of capitalism, nor of socialism, but of the managerial society.

In this article the word 'administration' is used to cover not only the wide and general field of the management of affairs, and determination of policy at the highest level, but the work of an executive (in the American sense), and it includes management generally in its various degrees down to the level of supervisor. These various functions may be widely different on the surface but the levels tend to merge into one another, and the underlying science of management is the same throughout, although as the ladder is climbed the horizon becomes wider.

The goal of administration is the right ordering of an organization or enterprise towards a predetermined objective for profit—profit not to one particular person or group, but to all concerned in the enterprise. Now an enterprise does not consist of material things such as buildings, tools and equipment, but of people—the owners, managers and workers within it. It is an association in which men come together for a common purpose, to produce material goods or to provide some service through remunerative work, and this work must be remunerative to those within the enterprise and profit those to whom the goods and services are supplied.

It will thus be seen that the primary end of administration is always the human being, and therefore the essence of administration is human relationships. This point is fundamental and so important that it can hardly be over-emphasized, although it seems to be frequently neglected in management.

Human relations has been defined as that system of means and methods which seeks to improve the organization and conditions of the worker, with the object of securing a bigger and better output. This definition is, however, only partial; it deals with human relations only in so far as this affects the material objective of production, and it does not cover that full relationship between human beings which enables them to satisfy their moral and material needs and in the end to achieve their ultimate destiny.

Effective human relationships cannot exist in an enterprise where the management is overbearing and where the workers are like slaves. Nor can they exist if the workers are treated as irresponsible children whose material and moral needs are automatically provided for, in the shape of houses, amusements, social and medical services—indeed, almost everything. Such paternalism is more likely to produce resentment than co-operation.

Since human relations concerns the relations between men, it is obviously necessary, if it is to be understood fully, to consider and examine the nature of man and the ideas which motivate him in his work. Man is not just an economic unit acting strictly in accordance with economic laws. Neither is he a mere animal having only material wants and desires. Nor can he be treated from a mechanistic point of view, like a free atom in a gas following a random path whose motion is completely conditioned by exterior forces and physical environment.

Man has at once a material and spiritual element, a body and soul united to form one complete individual with an ultimate purpose. He is, moreover, not an isolated entity—he is born into the primary society of

the family and lives in, and forms part of, larger associations and communities with which he acts. If joined with others in an industry or enterprise he will not work as an individual but as a member of a team or group.

By his nature man will seek to attain his end—perfection of his personality—whether he may explicitly realize it or not, and work is one of the means whereby he may perfect his nature. Notwithstanding the fact that work was, in the beginning, put on man as a curse, it was also natural to him, and he has been given an urge to produce material things by using his hands and his intellect; so that if man must work he can at the same time achieve through it happiness and the satisfaction of accomplishment. It is also true that normally a man likes his work; if he does not, the fault lies generally in the prevailing psychological and social conditions.

Work gives man a status and binds him to society, and through it he can obtain the respect of his fellow men. Whether a man likes his work or not bears no simple and direct relationship with the material environment associated with it. Very often when conditions are at their worst morale is at its highest.

If human relationships are really to be complete and integral they must so order the organization that the worker, a human being, can perfect his nature by fulfilling his material, social and spiritual needs through remunerative work. In so doing he profits the owners and shareholders together with all those associated with the enterprise and indeed the community at large, thus furthering the common good. If, therefore, human relationships are to be complete and fruitful the manager must recognize that the worker is a free human being with inalienable rights and with an end which transcends material things; he does not exist merely to produce goods—goods are produced for his benefit and use. The manager must recognize that man is naturally social and will combine with other men for a given end, and that in so doing he will not act individually but as a member of a group or team, and that he will take an interest in and work for the welfare of the group to which he freely belongs.

The wise administrator will, accordingly, use all the means at his command to develop the feeling of group membership and to help co-workers to understand each other. He will carry this feeling to the enterprise or industry as a whole, so that its members will refer to it as 'my firm' and will have a feeling that they really belong, that they matter, that they are wanted; so that the worker will come to regard the successes, failures, and achievements of the enterprise as his own.

To do this, the worker must be taken into the confidence of the management and given all possible information on the policy, plans, profits and products, the aims and targets, indeed everything appertaining to the enterprise. His suggestions should be welcomed and, so far as possible, he should be consulted on innovations and developments. If this is done the worker will realize that he is being treated as an individual personality with human rights and dignity, and he will accordingly act with confidence as an intelligent member of a team. These ideas are epitomized by the Irishman Edmund Burke:

> No men can act with effect who do not act in concert; no men can act in concert who do not act with confidence; no men can act with confidence who are not bound together with common opinions, common affections and common interests.

Now, it may be urged that these are very nice theoretical principles, very good and true in their own way, but they have little relation to everyday affairs, nor are they really applicable in the hard world of business and industrial production with which the administrator is immediately concerned. In order to test the validity of this argument let us examine the results of some practical investigations carried out in the United States by Elton Mayo.

Mayo was an Australian by birth who became Professor of Industrial Research at the Harvard Graduate School of Business. Initially he approached management problems from the point of view of the mechanistic individualist psychology, in which man's work was governed by the material conditions existing on the job; but after both an investigation he undertook into a quite abnormal labour turnover in one section of a textile mill, and the now famous Hawthorne experiments, he changed his views radically and laid the foundation for a completely new outlook among industrial psychologists towards human relations in industry.

The Hawthorne experiments were carried out over a period of four years between 1924 and 1927 in a works of that name in Chicago. It was a large works employing some 30000 people, for whom advanced social and welfare schemes were provided. There had been considerable grumbling and dissatisfaction among the workers and at the same time the management were concerned at the level of production and output.

Industrial consultants and efficiency experts, called in to advise on the trouble, attempted altering working hours, changing the length and spacing of rest periods, the intensity of lighting, and other environmental conditions, but always with inconclusive results. These experiments assumed, in accordance with the ideas of the time, that the worker must be studied as an isolated unit, an economic man who, resembling a machine, could have his working efficiency scientifically measured. It was, moreover, assumed that this efficiency was conditioned by three main factors, wasteful or ineffectual movements in doing work, fatigue due to physiological reasons, and defects in the physical environment, for example poor lighting or inadequate heating.

Mayo started his investigations by using the classical methods of the time, but in order to reach a more definite and precise conclusion he arranged for two groups, as similar as possible, to be employed on exactly the same work. In one group the conditions were to be kept constant whilst in the other the lighting conditions were to be so varied that an exact appraisal of its effect could be made. When the lighting was increased the production went up not only in the test group but in both groups. The lighting was then reduced for the test group and

quite inexplicably the output of both groups again increased.

A factor hitherto unknown and unaccounted for had emerged, and Mayo must certainly be given credit for seeing that here was something new and important.

The investigations were continued by selecting two girls and asking them to select for themselves four others to make one group of six which was employed on the assembly of telephone relays. The basic production was to be noted so that when various changes in conditions were made the consequent variation in output could be used to measure their effectiveness. An observer was to stay with the group noting everything that went on, and—and this is the crucial point—keeping the workers informed on the progress of the experiment, asking for advice or information, and listening to complaints. The results of the main changes in the conditions of work which were made are summarized as follows:

1. During normal conditions of a 48-hour week a worker produced 2400 relays.
2. The group was put on piece work, and output rose.
3. Two five-minute rest pauses were introduced, one in the morning and the other in the afternoon; output rose again.
4. The rest pauses were increased to ten minutes instead of five—and output rose sharply.
5. Six five-minute pauses were introduced; the workers complained and output fell.
6. A return was made to two rest pauses and a free meal was supplied; output rose.
7. The working day finished at half-past four instead of five o'clock; output rose.
8. Work was stopped at four o'clock; output remained unchanged.
9. Finally all improvements were taken away and conditions reverted to those existing at the beginning of the experiment—a 48-hour week, no rest pauses and no free meal. Output rose to its maximum of 3000 relays a week per worker.

What are the implications of this experiment? And what conclusions can be drawn from it? First, that the workers' whole attitude had been changed since they had been treated as definite persons within a social group. Secondly, by being asked for help and advice they were made to feel important, that they mattered, and they were shown that they had a purpose and were necessary to the company whom they could help to solve a problem.

Let us now see what industrial psychologists have to say about the Hawthorne experiments. Stuart Chase in his books 'The Proper Study of Mankind' and 'Men at Work' comments:

> It had been demonstrated that industry apart from the production of goods had also a social function to perform; that the primary group rather than the individual should be the basic unit of observation . . . and that adequate motivation is more important than conditions of physical environment.

He then draws the conclusion:

> A factory performs two major functions: the economic one of producing goods and the social one of creating and distributing human satisfactions among the people under its roof. . . . If a factory's human organisation is out of balance all the efficiency systems in the world will not improve output.

Another writer, Gordon Rattray Taylor, points out:

> The results have been astonishing. Not only has friction been reduced but the technical efficiency of production has been raised, so that output has risen in a double sense.

It should be noted here that these men are not concerned with the niceties of sociological theory but with the concrete problem of increasing production by studying the workers' reactions.

The results of the Hawthorne experiments were empirical and it could therefore be argued by some that for this reason they were not universally valid. To this it can be replied that if the results do not establish principles they are, at least, in accordance with the principles of sociology which define the nature and end of man, and his place and rights in society.

The administrator should, indeed must, always bear these principles of sociology in mind when dealing with human relations, otherwise he will surely fail. No engineer needs to be reminded that his work will not be sound if he does not base it on sound first principles—no structure will be lasting which has not firm foundations.

The administrator must always remember these principles, that men are not just accidents required for production, they are an integral part of an enterprise and they have, if not an economic ownership, a kind of moral ownership of the end product which is the output of their labours, the result of the work done by their intellects and hands. Success must be measured not merely by material achievements but by the overall development of the enterprise in the moral as well as the material sphere. Good labour relations must not be considered only as a means to an end, a useful tool in the transformation of matter; they are an end in themselves.

The whole subject of human relations is a complex one with many facets. Only one or two of these have been touched upon here. That their application is difficult is certainly manifest to the administrator who has tried to put them into practice. Not the least of these difficulties is the fact that he is dealing with far from perfect human beings, men like himself with the same emotions, feelings, fears, and ambitions, with the same susceptibility to praise or blame, and sharing the same ultimate destiny. To overcome all the difficulties and disappointments requires humility and courage, but the rewards are great. Let the administrator ponder on the words of the Irish philosopher, Bishop Berkeley:

> Whatever the world thinks, he who hath not much meditated upon God, the human mind and the *summum bonum* may possibly make a thriving earthworm, but he will indubitably make a sorry patriot and a sorry statesman.

Finally, let the administrator always guard the true dignity and intrinsic worth of man, for if the idea comes to be generally accepted that man is the economic man postulated by the Manchester school, subject only to economic laws and sanctions, or that man is the animal man of the Freudian school, subject only to the laws of biology, or that technical progress is a full and complete end in itself, then our continent of Europe, which for over 2000 years has led the thought of the world, will become but a peninsula of Asia.

The New
RUGBY HIGH-FREQUENCY TRANSMITTING STATION

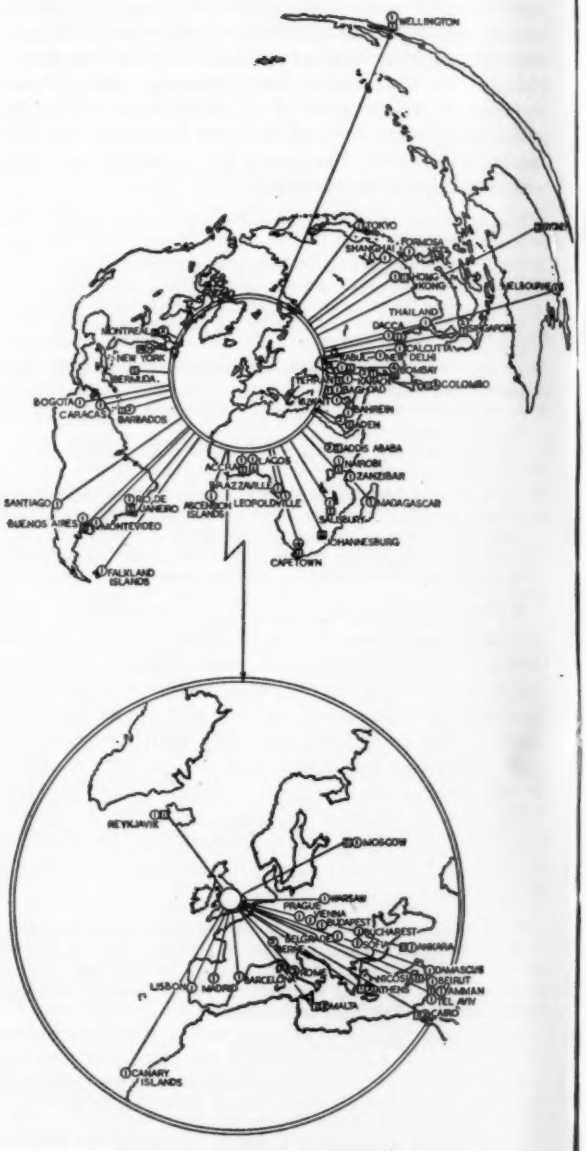
CAPT. C. F. BOOTH, O.B.E., *Member*
B. N. MacLARTY, O.B.E., *Member*

With her extensive oversea connections, Britain has always played a leading part in the development of international communication, and to keep pace with the continual growth of telephone and telegraph traffic a new radio transmitting station has been opened at Rugby. The authors have based this article on their paper (No. 1903), which was read at an Ordinary Meeting on the 3rd November, 1955, and was published last month in Part B of the Proceedings. Captain Booth is with the Post Office Engineering Department and Mr. MacLarty is with Marconi's Wireless Telegraph Co.

Introduction

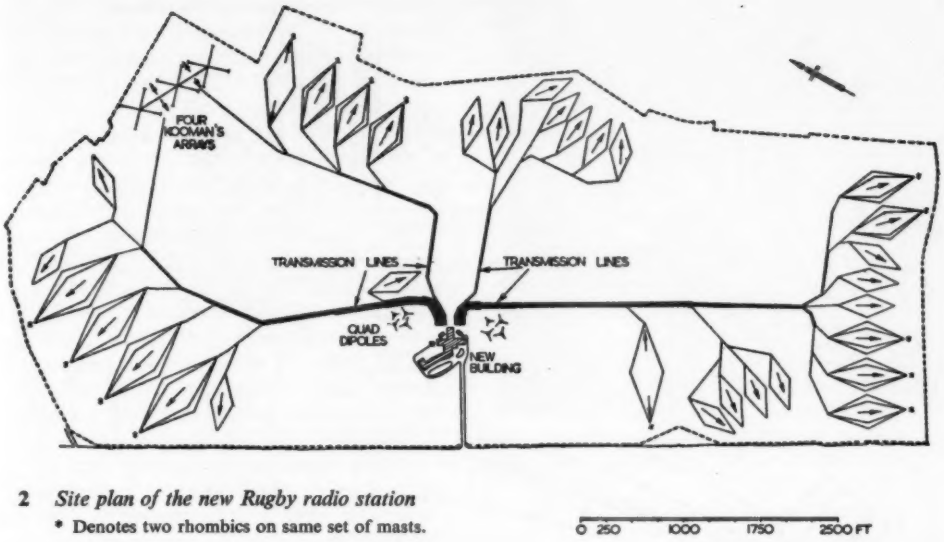
RAPID and reliable transmission of the spoken and written word between nations is assuming ever greater importance, and communication engineers the world over are engaged to an increasing extent on the problems involved. The United Kingdom has made important contributions to the art in the development of its communication channels to the Commonwealth and the rest of the world. These are provided by an integrated network of submarine-cable and radio circuits with facilities for traffic diversion between them. Improvement of the network is exemplified by the new transatlantic[1] telephone cable and by the development, over the years, of improved radio systems. The cables for which the United Kingdom is responsible, wholly or in part, comprise the Post Office telephone cables to the Continent, the new telephone cable to Canada and the United States, and the world-wide submarine-telegraph-cable system of Cable and Wireless, Ltd. The radio circuits, the United Kingdom terminals of which are operated by the Post Office, provide telephone and telegraph services to fixed stations and to ships at sea; a total of 23 stations participate, and the extent of the fixed radio services is illustrated in Fig. 1.

Despite expansion of existing radio stations and the provision of a new transmitting station at Criggion[2] during the war, it became apparent in 1945 that traffic growth would necessitate the provision of new transmitting and receiving stations. Planning was initiated, and a new transmitting station at Rugby was brought into service in October, 1954, a new receiving station at Bearley, near Stratford-on-Avon, having already begun



1 *Oversea point-to-point radio services operated in the United Kingdom by the Post Office*

□ Number of telephone channels.
○ Number of telegraph channels.



2 *Site plan of the new Rugby radio station*
* Denotes two rhombics on same set of masts.

operating in February, 1953. The purpose of this article is to outline the design of the new Rugby h.f. station, which houses 28 high-power transmitters operating on frequencies between 4000 kc/s and 27 500 kc/s, and—using upwards of 70 aerials—will give telephone and telegraph services to most parts of the world.

Basic Design Characteristics

For economic and operational reasons, and despite the wide variety of requirements, which include multi-channel telephony and several systems of telegraphy, it was decided to standardize much of the transmitting equipment. This has been achieved by dividing a given transmitter into two parts, a low-power drive unit and a high-power transmitter-amplifier; the latter (the larger and more costly part) is suitable for all classes of service. The low-power fixed-frequency drive units are of two types, one for multi-channel[3] telephony, and the other for telegraphy. Future changes in the demand for the different classes of service are catered for by the provision of alternative drive units on 12 of the 28 transmitters. A transmitter-amplifier accepts the low-power signals from its drive, converts them to the final frequency and raises them to high power.

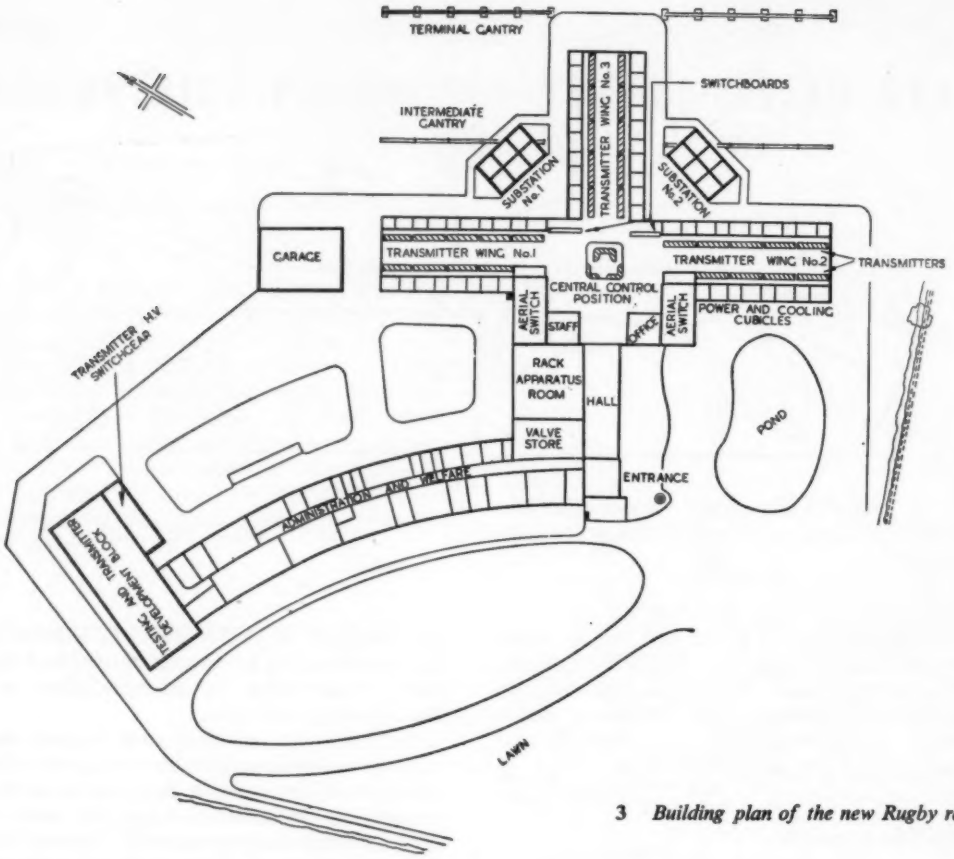
To reduce the costs of staff much use has been made of remote control and monitoring, and all the transmitters can be operated from a central control position. The low-power equipment is concentrated in one room from which connections are made to the transmitter-amplifiers. Initially, consideration was given to grouping the latter in several unattended buildings close to the aerials they would normally serve, in order to reduce feeder losses as compared with the losses of longer feeders necessary when all transmitters are grouped in one building. However, this advantage was considered to be less than the countervailing advantages of improved flexibility and easier maintenance for an installation in the single building finally adopted.

Although the internationally agreed standards in respect of frequency stability,[4] spurious emissions, etc., are relatively tight, it was clear that space for additional channels in the spectrum would be found mainly by a more general compliance with the standards, and by their upward revision at some future date. It was therefore decided that the overall performance of the new transmitter should be in advance of present standards.

Because of their simplicity, good all-round performance and wide frequency coverage, it was decided to use rhombic aerials, the one exception being the aerials for the New Zealand service. In the system of transmitter–aerial switching adopted, the transmitters and aerials are divided into two equal groups, with full flexibility within groups and cross connections between them. For the transmitter–aerial connections, coaxial cables are used within the building and open-wire feeders outside, the two being interconnected by exponential matching lines.

Site and Building

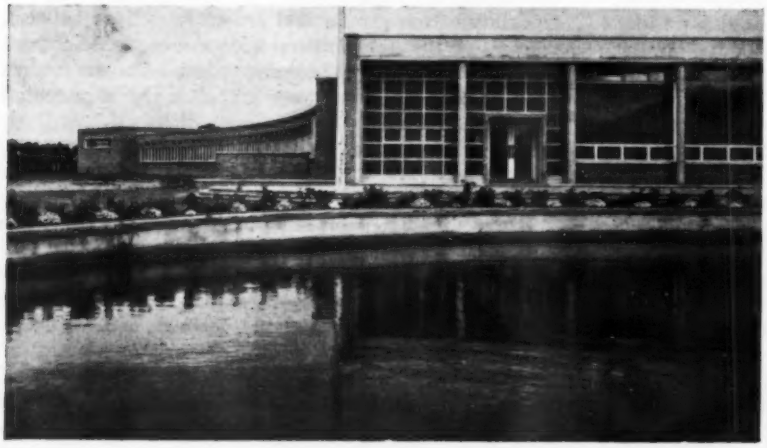
It was found that the site requirements, i.e. adequate area of flat land of good electrical conductivity, with no high ground subtending an angle of more than a few degrees at the boundary, access to a reliable power supply and to the trunk cable network, and adequate housing and amenities, would best be met by ground near the existing Rugby[5, 6] transmitting station, and some 700 acres of mixed arable and pasture land were purchased. Fig. 2 shows the site plan. The single-storey



3 *Building plan of the new Rugby radio station*

building is divided functionally; the layout and key plan are shown in Fig. 3 and the general appearance may be seen from Fig. 4. The curved wing contains the administrative and welfare accommodation. Each of the three wings housing the high-power transmitter-amplifiers is designed to accommodate two rows of five transmitters, and is flanked on either side by cubicles, two being assigned to each transmitter. One is for the oil-filled equipment and is fireproof; the other houses air-cooling equipment. The intersection of the wings contains a glazed enclosure housing the central control position, which is raised above the general floor level to give a good view of the wings. Adjoining the central area are a room housing the low-power equipment and two rooms containing the switches through which the transmitter outputs are connected to the aerials. Behind the wings, i.e. on the side remote from the main entrance, are two separate substation buildings.

4 *The entrance and curved wing of the new building*



Internal Plant

Excluding the power equipment, the internal plant comprises the following major items: the land-line equip-

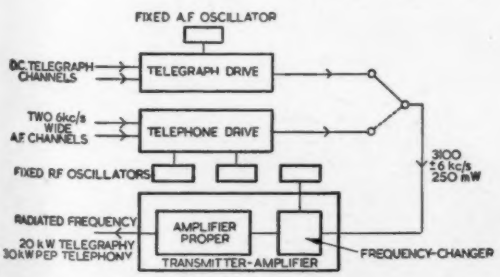
ment, the transmitter drive units, the fixed-frequency oscillators, the monitoring equipment, all of which are installed in the rack-apparatus room; the transmitter-amplifiers, the control position, and the aerial switches, which are installed in or near the transmitter wings.

The land-line circuits connecting the telephone and telegraph terminal offices in London to the new station terminate in the rack-apparatus room, where they are connected, through equalizers and amplifiers, to the telephone and telegraph drive units. A drive unit, Fig. 5, translates the land-line signals into a frequency band centred on a low-level pilot carrier of 3 100 kc/s. The signal is then passed through a 75-ohm cable to a transmitter-amplifier, where it is changed to its final frequency before being applied to the amplifier proper. In a telephone drive unit the two audio input channels pass through separate chains, one being translated to the band 94–100 kc/s and the other to the band 100–106 kc/s. These signals are then combined, and together with a 100 kc/s pilot carrier are fed to a second modulator, where the composite signal is translated to a band centred on 3 100 kc/s, and raised to a level of 250 mW. A telegraph drive unit provides a 3 100 kc/s keyed signal for several types of emission, including single- and two-channel frequency-shift keying and single-channel on-off keying.

The internationally agreed frequency tolerance for the transmitters, ± 30 parts per million, is met with some margin; the 100 kc/s and 3 000 kc/s carriers for the telephone drive units are derived from a 100 kc/s frequency standard, and the carriers for the final frequency-changers are derived from crystal oscillators. A frequency-measuring set is provided on which the frequency of any of the oscillators can be quickly determined by the station staff.

Automatic signal monitors check operation on telephone and telegraph signals; the signals arriving at the station over the land-lines are compared in terms of their envelope for telephony, and element by element for telegraphy, with those derived from the outputs of the associated transmitters, alarms being given of faulty operation. Further automatic supervision is provided by carrier-level monitors in the transmitter output circuits, and by reflectometers which check the input impedance of the aerial transmission lines.

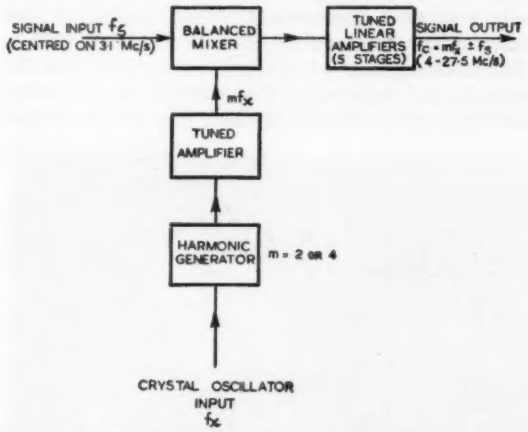
A transmitter-amplifier consists of a frequency-changer and linear-amplifier, and is contained in an enclosure



5 *Block schematic showing relationship between drive units and other equipment*

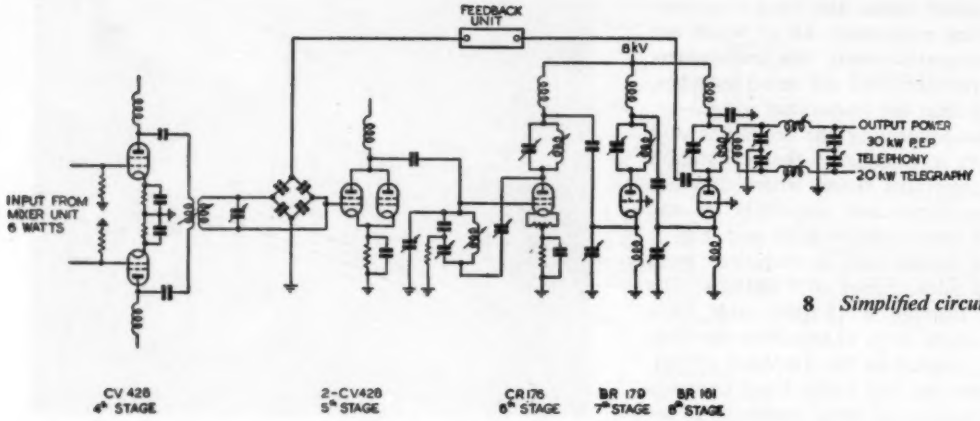
6 *View of the transmitter wing looking towards the central control position*

20 ft long, 3 ft 9 in wide and 7 ft high; a view of a transmitter wing looking towards the central control is shown in Fig. 6. The function of the frequency-changer is to translate the drive-unit signal to its final frequency, in the range 4 000–27 500 kc/s, before passing it to the linear-amplifier, as shown in Fig. 7. To facilitate switching to


SIGNAL INPUT f_s (CENTRED ON 31 Mc/s)
BALANCED MIXER
TUNED LINEAR AMPLIFIERS (5 STAGES)
SIGNAL OUTPUT $f_c = mf_x \pm f_s$ (4-27·5 Mc/s)
mf_x
TUNED AMPLIFIER
HARMONIC GENERATOR
m = 2 OR 4
CRYSTAL OSCILLATOR INPUT f_x

7 *Block schematic of mixer and linear amplifier*

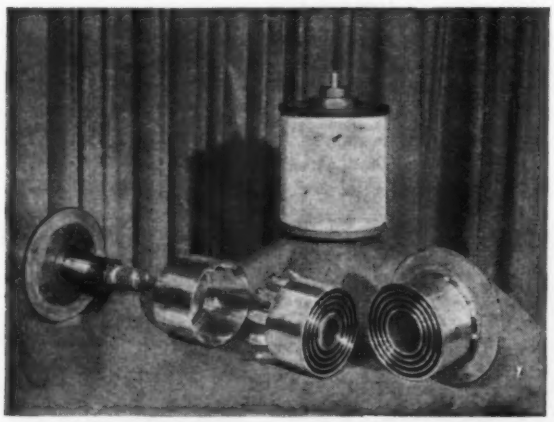
any of six spot frequencies, six pretuned units are used, the 3 100 kc/s signal being fed to all the units and the desired one selected by switching its h.t. supply and output. The signal from the mixer is amplified through eight stages and a simplified circuit diagram of the last five stages is shown in Fig. 8. By the application of negative feedback from the anode of the final stage over the last four stages, the intermodulation products have been kept low. Because of the wide frequency range to be covered, unbalanced earthed grid circuits are used in the last two stages. The cathodes of the last three stages are



8 *Simplified circuit of linear amplifier*

heated by a d.c. supply derived from selenium rectifiers, and their h.t. supply at 8 kV is obtained from grid-controlled mercury-arc rectifiers. The transmitter-output and feeder-coupling circuits function both as impedance transformers and as harmonic filters; at full power (30 kW) telephone operation, and at a power of 20 kW on frequency-shift telegraphy, the harmonic power is generally less than 20 mW.

The requirement for rapid adjustment by remote control to six predetermined frequencies is met by circuits built with continuously variable inductors and capacitors. The continuously variable inductor used in the last three stages is wound with copper tube and has a spring-loaded spherical sliding contact. In the design of a continuously variable capacitor (Fig. 9) for the last three stages, air-dielectric units were ruled out because of bulk and high self-inductance, and a small capacitor was developed using sulphur hexafluoride gas, under pressure, as a dielectric; coaxial electrodes give a large change of capacitance with small residual inductance.



9 *Variable capacitor*

The height of the assembled capacitor is about 7 inches.

The valves and circuit components of each of the last three stages are contained in aluminium cabinets, the valves being mounted anode downwards, and air-cooling being used. Considering the final stage, the anode is supported by a shelf, which acts as insulator and air baffle, the anode circuit being directly below the valve. Above the shelf, at the level of the valve grid-seal, is a metal screen to which the grid is earthed through blocking capacitors. Cooling air is drawn in through a filter at the top, through the valve anode fins and out through an aperture at the base of the box; the warm air passes through a channel in the floor to an exhaust fan in the adjacent cubicle and is then either discharged outside the building or is used to heat the building. Mechanical interlocks give full protection to the operating staff; limited access is allowed without switching off the filaments, but no points carrying dangerous voltages can be reached.

The function of the control officer at the central control position—the nerve centre of the station—is to ensure

10 *View of the central control position*

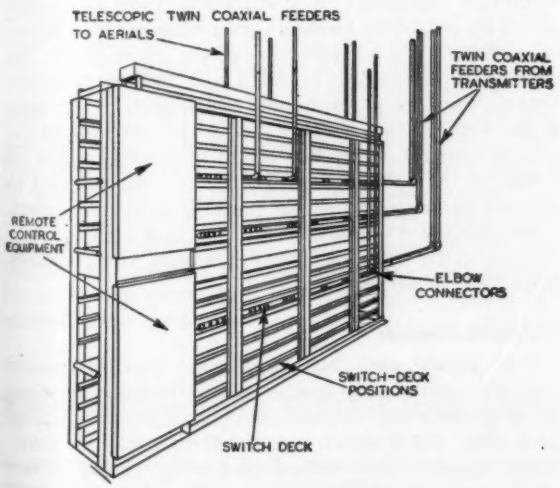
that the services required by the terminal stations in London are correctly and quickly provided. The position is equipped with remote-control and monitoring facilities for each transmitter, and communication by order wire direct to the London terminals, by loud hailer to staff patrolling the transmitter wings and by telephone to various strategic points. The controller can also bring up each transmitter on any of its predetermined frequencies, connect it to one of several aerials, and shut it down. He knows whether or not the station plant is functioning correctly, and if a fault develops he is made generally aware of its character. Each transmitter has a separate control unit, and these are accommodated on the control desk, Fig. 10.

Aerial-Switching Equipment

Twin coaxial feeders, balanced to earth, carry power from the transmitters to the aerial switches, and from the switches to the exponential lines and thence to the aerials via open-wire feeders. Fourteen transmitters and 36 aerials can be connected to each of the two aerial switches, which are interconnected by junctions. Each of the two switches comprises a bank of 14 *switch decks* mounted horizontally one above the other, as shown in Fig. 11. A switch deck consists of twin-coaxial feeders joined to a transmitter, with side outlets for the aerial connections; the vertical twin feeders to the aerials hang on either side of the switch decks. The inner conductors of the horizontal feeders in a switch deck are interrupted by switches at each aerial side outlet, and these are operated from the central control position.

External Plant

The layout of the aerials and transmission lines is shown in Fig. 2. At present there are 46 large and small rhombics, 4 Kooman's arrays and 8 quadrant dipoles.



11 *Aerial switch showing three switch decks in position, two being connected to two aerials*

The rhombics are of the triple-wire type and are terminated in iron-wire dissipation lines. The small rhombics, mounted on 75 ft poles, are used where gain at low angles and low frequencies is not of great importance. For high gain, pairs of larger concentric rhombics, mounted on 150 ft steel masts, one at a height of 75 ft and the other at 150 ft, are used. To cater for the wide deviations from the great-circle path occurring on the New Zealand service, Kooman's arrays on 325 ft steel masts are provided; the reflector and radiator curtains can be interchanged remotely for long- and short-path transmission.

The exponential matching lines connecting the coaxial and open-wire lines terminate on gantries; each uses four wires, the horizontally adjacent wires being in parallel, and the wire spacings are tapered both in elevation and in plan. The two wires of an open-wire line are mounted one above the other, at a mean height of 16 ft above the ground.

Power Supply

Power drawn from the 11 kV mains, or from an emergency supply, is fed to the two interconnected substations by separate underground feeders. Each substation contains three 500 kVA transformers, two working and one spare, and the transmitter-amplifiers are fed in groups from two medium-voltage switchboards in the transmitter wings. Since the grid-controlled mercury-arc rectifiers in the transmitters will clear overloads faster than a circuit-breaker, the medium-voltage feeders are protected against only catastrophic failures, high-rupturing-capacity fuses being used in the grouped and individual supplies.

Performance

Although time is young—the first transmitters were brought into service only about a year ago—experience has clearly confirmed the advantages of using a common type of high-power linear amplifier with either telephone or telegraph drive units. The flexibility provided by this and by the aerial-switching arrangements has proved itself. The remote-control and monitoring facilities have worked well and will lead to substantial savings in operating costs.

References

1 KELLY, M. J., RADLEY, W. G., GILMAN, G. W., and HALSEY, R. J.: 'A Transatlantic Telephone Cable', *Proceedings I.E.E.*, Paper No. 1741, September 1954 (**102** B, p. 117).
2 WEST, W., COOK, A., HALL, L. L., and STURGESS, H. E.: 'The Radio Transmitting Station at Criggion', *Journal I.E.E.*, 1947, **94**, Part IIIA, p. 269.
3 BRAY, W. J., LILLICRAP, H. G., and LOWRY, W. R. H.: 'The Design of Transmitter Drives and Receivers for Single-Sideband Systems', *Journal I.E.E.*, 1947, **94**, Part IIIA, p. 298.
4 BOOTH, C. F.: 'The Evolution of Frequency Control', *Proceedings I.E.E.*, 1951 (**98**, Part III, p. 1).
5 SHAUGHNESSEY, E. H.: 'The Rugby Radio Station of the British Post Office', *Journal I.E.E.*, 1926, **64**, p. 683.
6 HANSFORD, R. V., and FAULKNER, H.: 'Some Notes on Design Details of a High-Power Radio-Telegraphic Transmitter using Thermionic Valves', *Journal I.E.E.*, 1927, **65**, p. 297.

Field Estimation

A short review of a Graduate and Student Section paper entitled 'Field Estimation with Particular Reference to the Magnetic Field of Rotating Machines', by G. D. Stairmand, M.Sc., B.E., Graduate. The paper was awarded a Students' Premium by the Council and a long abstract of it was published in March, 1956, in the Students' Quarterly Journal.

ASSOCIATED WITH THE INCREASED USE OF ROTATING machines is the necessity of reducing the size and material of any machine to compete successfully in world markets. To produce the simplest, most economical and efficient machine an accurate knowledge of the magnetic field is desirable. On the test bed, the field may be determined with considerable accuracy, but to obviate the costly modifications sometimes necessary at this stage, it is preferable to employ some means of predetermination.

The Magnetic Field

A magnetic field may be defined as a form of magnetic stress existing in space. This magnetic stress produces an effect in certain materials, and the fact that the region under stress is now different from its previous condition, when there was no nearby magnetic influence, is explained by the hypothesis that the region now contains a field of strength H, which is indicated by lines of force or flux. There are two very important properties of the two-dimensional magnetic field that may be easily proved. They are best expressed in the form of equations and define the magnetic potential and flux at any point. If H_x and H_y are the field strengths in the x and y directions the magnetic potential P in air is expressed by

$$P = -\oint (H_x dx + H_y dy) \quad . \quad . \quad . \quad (1)$$

which is scalar and independent of the path of integration. In the current-carrying region the potential becomes a vector quantity, being dependent on the path of integration.

Also the flux Φ may be defined as

$$\Phi = \oint (H_x dy - H_y dx) \quad . \quad . \quad . \quad (2)$$

which embodies the principle of conservation of flux.

Flux and potential may be shown to be harmonic functions, i.e. solutions of Laplace's equation. Also, as flux and potential satisfy the Cauchy–Riemann equations, they are conjugate harmonic so that the field may be represented by two sets of curves which everywhere have the property of orthogonal intersection. Thus the solution of these problems revolves mainly around the evaluation of Laplace's equation in the region where there is no current and of Poisson's equation in current-carrying regions.

The methods that may be used readily divide themselves into groups: mathematical, graphical, analogical, and practical.

Mathematical Methods

An analytical method of approaching the problem is unfortunately not easy, the main difficulty being the extremely complicated mathematics that is encountered when the boundaries are not simple. A solution of the equations is itself complicated as the terms it contains are made up of a constant, and trigonometric and hyperbolic functions:

$$P = A_n \cosh \beta_n y \cos \beta_n x + B_n \sinh \beta_n y \cos \beta_n x + C_n \cosh \beta_n y \sin \beta_n x + D_n \sinh \beta_n y \sin \beta_n y$$

For any given boundaries to which this equation can be adjusted the constants of each term, A_n, B_n, C_n, D_n, must be determined to satisfy the imposed boundary conditions.

The most used methods of mathematical evaluation are numerical, employing successive approximations to the value at a point. The methods differ only in the means of correcting the assumed initial values. The field under investigation is split into a mesh of squares, and initial values are placed at the nodes of the lattice so formed. By using the method due to Professor Thom, the values at the nodes are changed by a system of cross-averaging until steady values are obtained. Southwell's method of systematic relaxation of constraints, more commonly called the *relaxation method*, uses a more refined method of correction. By consideration of the initial values, the *residual* at each node is found. These residual values are then adjusted, with appropriate adjustments to the value at the node, so that they are gradually moved out to the edge of the plot, where they are of little consequence. In a field of the Laplace type the residuals are reduced to zero but in a Poisson field the residuals have finite values. These successive evaluations are tedious if high accuracy is required but are a useful tool especially with the aid of some form of calculating machine.

Graphical Methods

For complicated boundary conditions the more frequent method employed is that of free-hand plotting. Lines of force and equipotential lines are orthogonal to each other and if drawn together form a mesh of curvilinear squares. This method of plotting is due to two main exponents, A. D. Moore and Th. Lehmann, both of whom independently evolved the method. Much design data and curves are built up by this method but

facility in flux plotting is acquired only after hours of persistent endeavour on the solution of field problems. In air, by using known solutions for particular configurations, a plot of curvilinear squares may be made, but in the current-carrying regions the equipotentials no longer exist. They may, however, be projected into the coil as lines of no work, which are orthogonal to the lines of force. These lines of no work converge to a focus, the position of which is found by trial and error, and they divide the coil into sections such that the ratio of the magnetomotive forces enclosed by the lines of no work is the same as the ratio of the equipotentials of which they are the continuation.

Analogues

Another important method of predetermination is the use of an analogue, of which there are numerous types, but many of these are highly specialized. Within recent years the technique of the electrolytic tank has been widely applied but this is difficult to use with Poisson fields; paper has been used as an electrolyte to enable the plot to be made direct.

Practical Methods of Determination

Of the more generally applicable practical methods, the most commonly used is the generator principle where a coil is mounted at the end of a spindle fitted as an extension to the shaft of a synchronous motor. This method has been fully investigated, the size of the coil and extension being reduced to that of a matchstick. The voltage from the coil causes a meter deflection, which is a direct measure of the field component perpendicular to the spindle at the point where the coil is located.

Other practical methods include the use of a coil and fluxmeter or ballistic galvanometer, or the use of the Hall effect in germanium in an instrument now made commercially. The latter has the best industrial applications but calibration has to be adjusted for each range of fields and the probe itself is temperature sensitive.

Germanium also has the property of increasing its resistance under the influence of magnetic fields, and the percentage change of resistance is independent of size so that the crystal used may be very small. It is claimed that by suitable ageing and cutting, a crystal that is free from both temperature and light variations may be produced. High sensitivity, stability and good response to transient and varying fields are advantages that are also claimed, but the use of germanium in this manner is still in the process of development. 621.313.1 : 621.3.013

A Method for Strip Transmission Lines

A synopsis of a Radio and Telecommunication Section paper (No. 1991) entitled 'An Investigation into Some Fundamental Properties of Strip Transmission Lines with the Aid of an Electrolytic Tank', by J. M. C. Dukes, M.A., Associate Member. The paper was published in May in Part B of the Proceedings.

THE PAPER DESCRIBES A METHOD OF DERIVING NUMERICAL values for quantities such as characteristic impedance, attenuation and wavelength with the aid of an electrolytic tank. Numerical results are given for two principal forms of strip transmission line for a range of dimensions for which rigorous solutions by direct analysis are not readily available. This range is nevertheless of considerable practical interest as it encompasses characteristic impedances between 20 and 150 ohms. The recent findings of Black and Higgens in regard to the inaccuracy of the formulae due to Maxwell and Palmer for the strip-above-ground system are confirmed. A new and simple method is derived for calculating approximate values for the pseudo-TEM impedance, wavelength and attenuation of a non-homogeneous dielectric-slab-supported strip-above-ground system (e.g. Microstrip). The numerical results obtained by this method, which depends only on a knowledge of the values for air-spaced lines, are in good agreement with measured results. As a result, it appears that the dominant mode propagating in a Microstrip line is more closely TEM in character than was hitherto supposed. In theory, however, there must exist a longitudinal component of the electromagnetic field if the boundary conditions are to be satisfied. Measurements on the electrolytic tank of coupling between adjacent conductors and of field spread are also described. From the analysis as a whole it would appear that the tri-plate (sandwich line) has certain theoretical advantages over the strip-above-ground system. However, these are likely to be offset by a number of important practical disadvantages. 621.372.2 : 621.317.6 : 621.317.729

Switchgear

A synopsis of a review of progress (paper No. 2012) with the above title by C. H. Flurscheim, B.A., Member. The paper is published this month in Part A of the Proceedings.

PREVIOUS REVIEWS OF PROGRESS IN THE FIELD OF SWITCHgear have been concerned with metalclad equipment and high-voltage circuit-breakers. The present review covers the field of indoor and outdoor alternating-current circuit-breakers and associated metalclad structures, with special reference to progress made since 1945.

In British switchgear, development during the period under review has been directed mainly towards the improvement of interrupting performance, measured by reliability and speed of interruption of short-circuits, and by the prevention of over-voltages when disconnecting open-ended lines or small reactive currents. It has also been directed towards reducing the size and costs of switchgear and the buildings in which indoor gear is mounted.

The techniques of oil, air-break, and air-blast interruption, and of multi-break design, with various forms

of voltage division, have all been exploited to assist in achieving these aims. There is now little room for further reduction in the minimum size of switchgear for a given voltage, but the MVA rating for the smallest frames, already doubled in this period, will no doubt continue to increase in the future.

The upper limit of megavolt-amperes has increased seven times in the period under review, and there are no obvious limitations to further progress; it is to be expected that the MVA rating available in circuit-breakers of British design will continue to exceed those required on contemporary networks. 621.316.3

Lighting of Radar Operations Rooms

A synopsis of a Radio and Telecommunication Section paper (No. 2023) entitled 'A Method of Increasing the Ambient Illumination of Radar Operations Rooms without Reduction of Signal Detection Threshold', by C. R. Barnard. The paper was published in March, 1956, in Part B of the Proceedings.

BY SUPERIMPOSING A NARROW-BAND-PASS OPTICAL FILTER on the face of a cathode-ray tube it is possible to achieve a high level of ambient illumination, provided that the distribution of the ambient lighting lies outside the pass-band of the filter. In a radar operations room with narrow-band orange filters over the displays and using deep-red and blue-green fluorescent lamps in inverted fittings to provide diffused lighting from the ceiling, a high level of illumination has been obtained as shown in the Figure, and the lighting appears white despite the marked orange deficiency.

Trials using identical displays in a blacked-out room as a control have shown that there is no reduction in the threshold of signal detection. The plotting-table operators have good colour discrimination except in the orange region of the spectrum, where certain orange pigments appear red, and the supervisory staff are able to move about freely, comparing radar data with the plotting-table information.

The installation in a radar track-telling room has been used operationally with apparent success. It has not been possible to determine whether or not there has been a reduction in operator fatigue, although, after becoming accustomed to the system, the operators have expressed a strong preference for working in the lighted room.

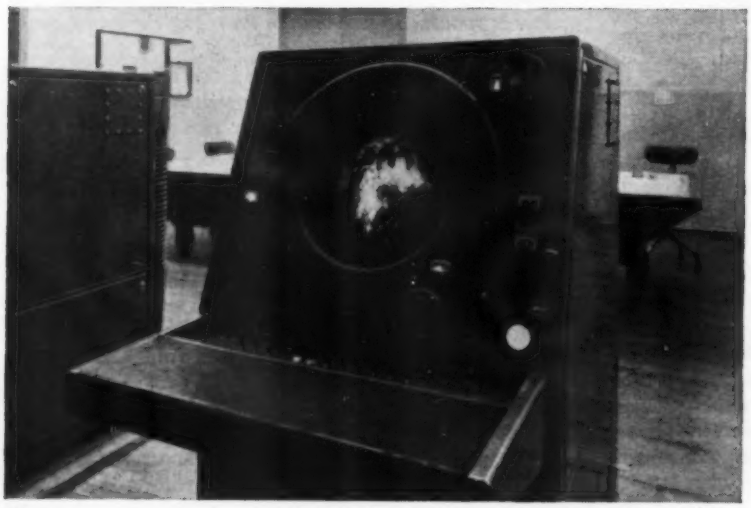
621.396.963 : 628.972

Coal-Mine Lighting

A synopsis of a Utilization Section paper (No. 2034) entitled 'Underground Lighting in Coal Mines', by C. D. J. Statham, B.Eng., Ph.D., M.I.Min.E., Member, is given below. The paper was published individually in March, 1956, and it will be republished in Part A of the Proceedings. No longer account of this 'integrating' paper is being included here, since it is already a survey covering many varied facets of the practice of lighting in coal mines and is written in a form that is easily readable by any electrical engineer whether specialized in illumination or not. An account of the meeting at which it was presented and discussed appears on page 344. Those members who are interested in Dr. Statham's paper and do not see Part A of the Proceedings regularly are advised to obtain a reprint of the paper when this becomes available (see page 356).

THE IMPORTANCE OF LIGHTING BELOW GROUND IS emphasized and the difficulties associated therewith are outlined. Inadequate or inferior lighting produces nystagmus, and the author mentions the decline in new cases since better lighting has been introduced.

Changes in portable lamps, to profit from improvements in technique and to suit alterations in mining



Radar display under high ambient illumination

methods, are reviewed, and typical modern equipment and methods of application are described. The author discusses the importance of photometry in lamp-room practice, and indicates recent improvements in bulbs and cables for miners' lamps.

It is desirable to extend the use of mains lighting below ground for both the roadways and the coal faces. Progress in this field is reviewed, together with descriptions of equipment and results obtained. Dr. Statham points out that the economics of the general introduction of mains lighting to coal faces is important; development is at present hindered by restrictions in the use of aluminium alloys in coal mines. 628.972 : 622.2

Self-service lamp-room

The miner puts his own lamp on charge after returning from work.

Electric Traction

A synopsis of a review of progress (paper No. 2074) with the above title by J. W. Grieve, B.Sc., Associate Member. The paper is published this month in Part A of the Proceedings.

SIX YEARS AGO THE CONVENTION ON ELECTRIC RAILWAY Traction reviewed electric traction with special reference to British Railways electrification at home and oversea, and the last ordinary progress review of this subject covered the period January, 1933, to December, 1936.

The present review does not include Diesel-electric traction, but generally records trends and developments in the intervening period with some reference to progress in most of the principal countries of the world.

There is no doubt that the most important feature of the period has been the development of electric traction using single-phase alternating current at standard frequency directly on the contact system, and the progress made in the application of this system has been very largely due to the imagination and drive of French engineers. 621.331

An Informal Evening—to discuss

ELECTRONICS AND AUTOMATION

Dr. Thomas gives a Talk, with Demonstrations, to the Radio and Telecommunication Section

The Committee of the Radio and Telecommunication Section have recently arranged some Informal Evenings to attract particularly the members of the Section who are interested generally in a subject but not in its specialized details. One of these was held on the 19th March, 1956, when Dr. H. A. Thomas of Unilever gave a talk on 'Electronics and Automation—Some Industrial Applications', during which he was assisted by a team of demonstrators who showed working exhibits of electronically controlled equipment automatically carrying out simple manufacturing processes, and a model of a well-known commercial computer. Films, one on automatic manufacture of radio equipment, and one on computers, were also shown at the meeting.

AUTOMATION is beginning to displace man's mental effort, just as mechanical aids very largely displaced his physical effort and produced the first industrial revolution. In opening the discussion on the 19th March, Dr. H. A. Thomas affirmed that control of a complex process by automation is a major step in production technique and can legitimately be called revolutionary.

For the United Kingdom, he said, the pressure of an ever-increasing demand for exports necessitated by an expanding population, together with a correspondingly increasing demand for domestic consumption by workers determined if possible to reduce, and certainly not to increase, their physical and mental effort, had created in

1 *Dr. H. A. Thomas among the exhibits at the meeting in The Institution's Lecture Theatre*

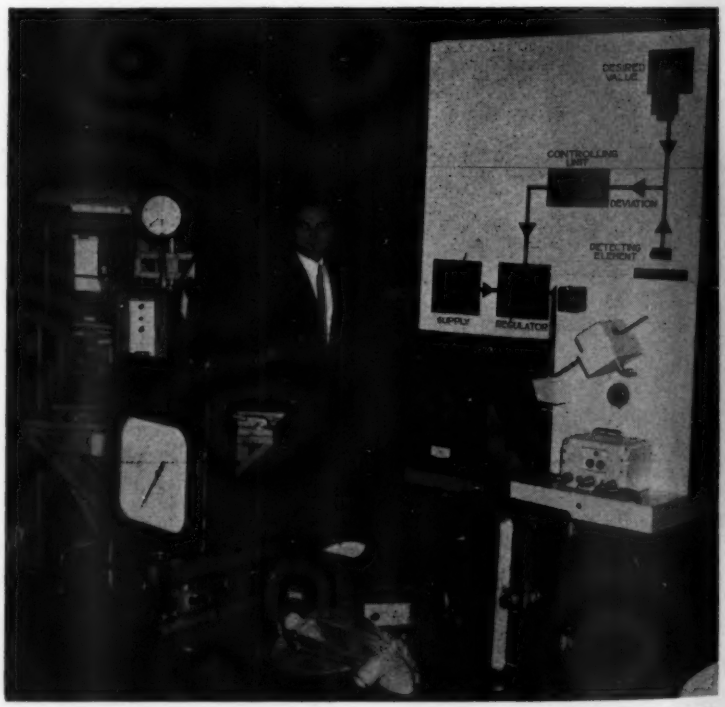
a competitive market a situation in which automation is one of the few remaining methods of maintaining our present standard of living.

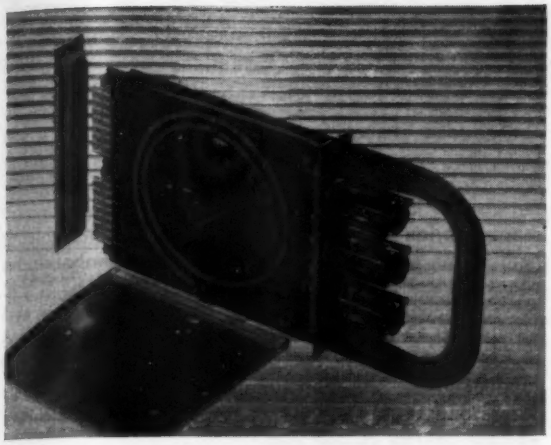
Definitions of automation range from the philosophic and almost theological, such as 'the way to a society in which labour is necessary not for the physical needs of the body but the creative needs of the soul' through vagaries such as 'any device in industry that saves drudgery, reduces risk to health, life and limb, or saves any form of human work,' to the matter of fact—'the science and art of manufacturing products with minimum labour effort and cost with maximum efficiency'. For his own part, Dr. Thomas said that he would suggest 'the substitution of automatic equipment for human mental effort'; this distinguishes between automation and mechanization —a distinction he thought of prime importance.

The technology of automation is largely an extension of the science of communication, and the developments in this field during the past twenty years have contributed primarily to the rapid development of control techniques; the prodigious wartime research on radar led to the two concurrent developments of pulse generation and servo mechanisms. Application of these techniques has produced the digital computers such as are now being used to handle wage payments, stores accounting, invoicing, market surveying and costing analysis.

In the fully automatic factory, which, according to Dr. Thomas, is not too far distant, production schedules initiated by management decisions will be introduced into a computer by punched cards or tape; control of the raw material and production requirements will be effected by automatic controllers and the information derived from the various electronic sensing and inspecting devices will be passed directly to the office, where it will provide automatically all records required for financial purposes. By such computer control it is now possible to extend the industrial use of end-point control whereby a signalled change in requirements of the end product automatically brings about the necessary changes at each point in the manufacturing process. Such control is already possible in a limited number of the already highly automatic process industries, such as oil refining; many other industries will find it possible to use such techniques once the potentialities are realized. If process control is used with insight and ingenuity, relief from the most repetitive forms of human work will become possible, and more rapid and less

2 *Mr. R. S. Medlock explaining a demonstration model of process control*





3 *Nickel delay-line package, as used in the Pegasus computer*
[From a film shown at the meeting.]

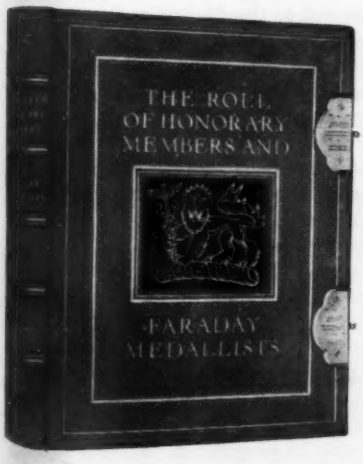
wasteful methods of increasing productivity will become available.

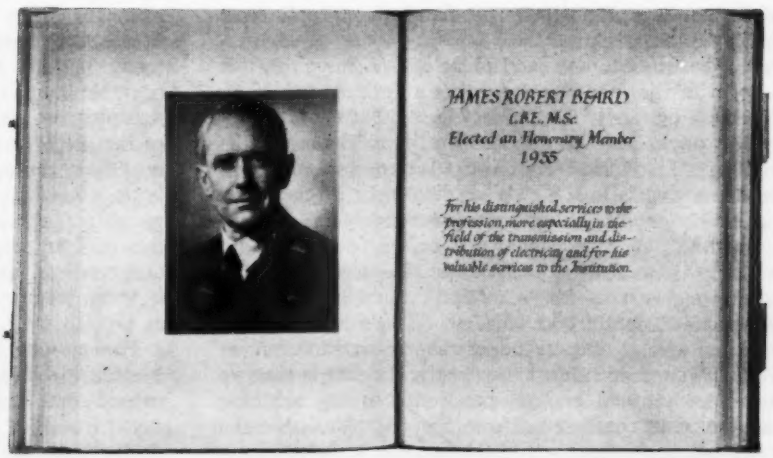
Six speakers took part in the brief general discussion which followed. Two further aspects of the use of electronics and automation which had not been brought out in the lecture were mentioned, namely their application to spectrographic analysis in industrial processes in which photomultipliers were used to give a direct-reading analysis of the product, and in flight simulation equipment and techniques. One speaker enquired about the life of valves in continuously operated electronic apparatus for automation. Dr. Thomas replied that lives of 5 000–10 000 hours might be expected in general, and he himself had experienced no great difficulties in this respect—in fact, the methanol detection equipment which he had described had run for 4 years at 24 hours per day with only occasional shut-downs.

Several speakers alluded to the possibility of redundant manpower after the introduction of automation processes and to the resulting problems. A plea was made for the training of specialist personnel to service automation equipment, since unskilled labour could not be used for this purpose, nor could it be carried out effectively by workers previously employed on ordinary maintenance duties.

The Roll of Honorary Members and Faraday Medallists

As noted on page 235 of the April *Journal*, The Institution now possesses a Roll of Honorary Members and Faraday Medallists in the form of a bound book, and H.R.H. The Duke of Edinburgh was the first of those who figure in the book to sign his name in it. A short description and photographs of the book, which has been designed and inscribed by Mr. George Mansell, are given here.




JAMES ROBERT BEARD
C.B.E., M.Sc.
Elected an Honorary Member
1955
For his distinguished services to the profession, more especially in the field of the transmission and distribution of electricity and for his valuable services to the Institution.

The book is bound and hand sewn in native oasis niger-morocco leather dyed to an ivory shade: there is a centre inset of blue Levant morocco leather, on which is tooled in gold leaf the crest of The Institution. The gold decoration consists of a specially designed repetitive ornament for the spine of the book and a decorative motif for the centre of the back of the book. The rules on the spine, front and back, are of proportional value and they and the lettering are tooled in gold. There are solid silver-gilt clasps, which are engraved with a specially designed monogram of The Institution. The edges of the book are gilt with gold leaf and the paper used in the book is stout hand-made English Whatman.

The photographs are unfadable carbon prints, and are dry-mounted. The roll entries and citations are written in Chinese stick ink in an Italic hand—in the style of the Chancery Renaissance script—while the title-page and sub-titles are set out in blue and black.

HOME EVENTS

LONDON

MEASUREMENT AND CONTROL SECTION
RADIO AND TELECOMMUNICATION SECTION

More Jobs for the Transistor

Three papers were read at a joint meeting of the Measurement and Control and the Radio and Telecommunication Sections held on the 27th March, 1956, with Mr. W. Bamford in the chair.

The first paper, *The Application of Transistors to the Trigger, Ratemeter and Power-Supply Circuits of Radiation Monitors*, by E. Franklin and J. B. James, was concerned with a very practical tool—a radiation monitor for use by geologists out in the wilds. With the aid of a common 4·5-volt dry battery and junction-type transistors, the authors showed how the necessary 6-volt, 400-volt and even 2000-volt stabilized power supplies can be provided to operate analogue types of ratemeter circuit, the total power consumption being only a few milliwatts.

The second paper, *A Point-Contact Transistor Scaling Circuit with 0·4microsec Resolution*, by G. B. B. Chaplin, dealt with point contact transistors for counting digitally at rates up to $2{\cdot}5 \times 10^6$ per second. His scheme was neatly illustrated with a model decade scaler comprising a ring of two (i.e. a binary scaler) followed by a ring of five, using seven transistors in all, the state of each transistor being monitored by a 6-volt lamp.

The third paper, *A Junction-Transistor Scaling Circuit with 2microsec Resolution*, by G. B. B. Chaplin and A. R. Owens, explored the possibility of using junction-type transistors to achieve similar ends although in this case, with the junction transistors at present available, the counting rate is reduced to $0{\cdot}5 \times 10^6$ per second.

The discussion was opened by a colleague of the authors, Mr. F. H. Wells, who adopted the standpoint of one who has to design a reliable piece of electronic equipment, and who asks 'can we safely do it with transistors?' He commented that before he actually did a job for himself using transistors, the literature on the subject appeared to him completely unintelligible. Some of us can therefore take comfort! The reliability theme recurred several times throughout the discussion but, as Dr. Chaplin made clear in his reply, the fact is that we have not yet had enough experience to say anything definite. One could sense from the discussion that the point-contact transistor and the junction transistor each has its champions, with, perhaps, Dr. Denis Taylor acting as referee and ensuring fair play for all. Dr. Chaplin himself clearly favours the point-contact type, although Mr. T. Walker chaffed him about being caught one day substituting junction for point-contact transistors in a certain computer circuit, when he apparently blushed and said he was only trying them! Mr. K. Cattermole made an interesting observation to the effect that, since transistor impedances are of the order of the impedance of free space, the transistor becomes an almost ideal device for high-speed working. It would have been surprising if the question of symbols had not been raised, and on this issue Mr. J. H. Barry is all for our keeping in step with the American system of graphical representation of transistors. It would not, he thought, be desirable to perpetuate what is a novel symbol in this country. Dr. Chaplin, however, would have none of this. 'Several speakers', he declared, 'have raised their eyebrows at the speeds achieved in the circuits. Perhaps the use of our symbol helps a little. We always put positive supplies at the top, and negative at the bottom, which allows current to flow vertically downwards, and hence we have gravity on our side.'

This humorous note brought to an end an otherwise serious and detailed discussion, and a vote of thanks to the authors, proposed by Mr. H. Stanesby, Chairman of the Radio and Telecommunication Section, was carried with acclamation. J. K. W.

UTILIZATION SECTION

Brighter Pits

'No single factor is of more importance to the mining industry than lighting.'

These very relevant words formed the opening sentence of an interesting paper entitled *Underground Lighting in Coal Mines*, which was presented at the meeting on the 15th March, by Dr. C. D. J. Statham, who in the course of his lecture outlined the difficulties associated with lighting below ground. A synopsis of the paper appears on page 340. He referred to the decline in the incidence of the eye disease of nystagmus among miners since better lighting had been introduced. Typical modern portable lamps operated from batteries were described, and progress was reviewed with regard to the extension of the use of mains lighting for both roadways and the coal face, the economic aspect being important in the latter situation. Two somewhat surprising facts were given in the paper, namely that there are some 14000 miles of underground roadways in British collieries along which men ordinarily travel, and that the first lighting underground utilizing mains power was installed as early as 1881.

The ensuing discussion was opened by Mr. B. L. Metcalf, who pointed out that since aluminium had caused some serious accidents because of its impact on rusty iron, its use had been banned, and this had undoubtedly put a stop to progress in coal-face lighting for the time being. He emphasized the necessity for increased collaboration between the lighting-fitting manufacturer and the machinery manufacturer, as there might be considerable saving if fittings were mounted on the conveyer.

One speaker was of the opinion that the time might come when the coal face would be completely mechanized and operated by remote control; thus no light would be necessary, and therefore the problem would solve itself.

Professor I. C. F. Statham (father of the author) expressed the view that, unlike other industries, improved lighting in mines had not so far effected an improvement in production. It had, however, played an important part in the improvement of health and in the reduction of accidents.

Another contributor, in referring to the point that the lack of progress in coal-face lighting is due to the impossibility of assessing the economic gain, said that instead of looking for resulting financial advantages the approach should rather be to regard such lighting as a means of improving working conditions. R. H. R.

BELFAST

NORTHERN IRELAND CENTRE

Something for Everyone

At the opening meeting of the 1955–56 Session in October, 1955, the Chairman, Major E. N. Cunliffe, delivered his Address on the subject *Problems and Progress in Electricity Distribution*. Major Cunliffe reviewed the growth of electrical demand in the province from 1896 (when electricity was introduced into Belfast) until the present time. The average increase in the Belfast area over that period was 7–8% per annum, and he explained how the problems encountered in the distribution of such rapidly increasing demands had been solved by improvements in technique, reinforcement of plant and increases of transmission voltages. A graphical analysis of system faults was given and developments in switchgear and transformer design were illustrated, particularly with regard to their effects on system reliability. In conclusion, the Chairman described a new 110 kV, oil-filled, 3-core cable then in course of installation between the new Municipal Power Station West and the system of the Electricity Board of Northern Ireland. This cable was the first of its kind in the United Kingdom.

As a contrast to the problems of the power supply engineer in meeting consumer demands, Mr. R. W. Palmer told us, at the second meeting of the session, about the *Maintenance Principles for Automatic Telephone Exchange Plant*. Despite the rather specialized nature of the paper, the ensuing discussion showed both by the number of members taking part and the diversity of their interests that there is something for all of us in every paper read. It is a great pity that many members attend a meeting only when the paper seems to have a direct bearing on their branch of engineering. The regular attenders fulfil one of the primary aims of The Institution by assisting in the broad dissemination of knowledge. In addition, they tend to lose that narrowness of vision which characterizes the 'boffin'.

At our December meeting we had the great pleasure of hearing Mr. J. F. Shipley, one of the Governors of the Incorporated Benevolent Fund, who told us how the fund was administered, and presented a film about 'The Chesters' residential estate at New Malden. The warm humanity and rich humour of the speaker did much to endear him and the Fund to those present. Two associated papers were then presented by Mr. H. Leyburn; these were entitled *Proving the Performance of Circuit-Breakers* and *A New Testing Station for High-Power Circuit-Breakers*. The ingenuity of improvisation in the development of tests for Super-Grid circuit-breakers aroused interest and admiration in many whose work had nothing to do with switchgear. Once again the discussion indicated that a specialist paper could be of interest to more than specialists.

At our fourth meeting *The Electrification of the Manchester–Sheffield–Wath Lines* was dealt with by Mr. J. A. Broughall. As Northern Ireland is fast losing the railways it had, and as considerable feeling has been aroused by the threatened closure of some of the remaining main lines, the paper was of great interest to everyone. The discussion may have been rather subjective and Mr. Broughall may have wondered what connection existed between it and the paper, but both paper and discussion contributed alike to an enjoyable and instructive evening. D. S. M.

LEEDS

NORTH MIDLAND UTILIZATION GROUP

A Keen Discussion of the Wiring Regulations

The 13th edition of the Wiring Regulations was issued on the 1st September, 1955, to supersede the 12th Edition, 1950, the Temporary Relaxation (of cable ratings), 1952, and the 1954 Supplement, which took account of new British Standards for rubber- and p.v.c.-insulated cables.

The North Midland Utilization Group thought the time opportune for a discussion of the new edition, and this was held at Leeds on the 13th March, 1956. Mr. Forbes Jackson, Vice-Chairman of the Wiring Regulations Committee, accepted their invitation to open the discussion, and Mr. D. B. Hogg, Chairman of the Utilization Section, was also the guest of the Group for the occasion.

In his introduction, Mr. Forbes Jackson drew attention to the notable tradition of the Regulations, beginning with the issue of the 1st Edition in 1882; the Committee on that occasion had included a high proportion of members who had either been, or later became, Presidents of The Institution. The present Committee, while its members might not all claim a similar distinction, was broadly based and maintained contact with all the bodies closely concerned. There was constant interchange with users of the Regulations and points raised were carefully sifted and preserved for use in the preparation of revised editions, which have appeared at approximately five-yearly intervals. Interim interpretations on points of

difficulty were available at all times through a specially appointed Committee, and those of general interest were periodically published in the *Journal* and the technical Press. Discussions such as the present meeting were valued by the Committee as they reinforced the existing procedure whereby comments received formed the basis of fresh revisions.

Fifteen speakers took part in a keen discussion. In general, the 13th Edition was thought to include many desirable features as compared with its predecessors and to have reduced the need for divergent special provisions in wiring contracts. In particular, where it had been possible to adopt a more positive approach in place of a requirement with exemptions, this method was preferred. The fuller treatment given to certain aspects, such as duct and trunking systems (Regulation 223) and connections to outbuildings (Regulation 229) was also appreciated.

Tribute was paid to the useful procedure of considering comments received during the preparation of a new edition, and examples were given of its efficacy in the past. The interpretation of points of difficulty was also a valuable service.

A number of informed and constructive suggestions were made which were noted for future use. In many instances these concerned matters which had been a subject of discussion for some time. The difficulty of carrying out alterations and extensions, as opposed to new installations, in full accordance with the Regulations was appreciated; for example, two-pin plugs and sockets remained in wide use despite the withdrawal of the exemption regarding earth-free situations from the requirement of earthing. The safe provision of electrical services in kitchens converted to serve also as bathrooms (see Regulation 405) remained a serious problem. The relative merits of ring-circuit systems and radial wiring for final sub-circuits were also touched upon.

A number of new points were also raised, for example the need for fuller guidance in Section 1 on control and distribution of the supply. One speaker thought that undue reliance should not be placed on colour identification of cables (see Regulations 206 and 504 and Table 7). The requirements for earth-continuity were discussed and it was hoped that in future these could be expressed less tentatively, more guidance also being given regarding the earth-continuity conductor of ring circuits. The merits of bonding of conduits and of motors, particularly where these were mounted on sliding supports, were urged.

In his reply, Mr. Forbes Jackson thanked the contributors for their suggestions, which he said would be of great help to the Committee, and gave his views on some of the technical issues raised. He hoped that other Centres would follow the example of the North Midland Group by arranging similar discussions.

NEWS *from Abroad*

COLOMBO

CEYLON OVERSEA BRANCH

At the twentieth Annual General Meeting of the Ceylon Oversea Branch, held on the 26th March, 1956, the Chairman, Mr. E. C. Fernando, gave his Address entitled *Electricity Supply in Ceylon*. He said that the picture of Ceylon's electricity supply industry is analogous to the development of Ceylon itself. The power cuts which had been experienced had been matched by the reversal of trade in recent years, when a depleted exchequer necessitated the severest economies. The power cuts, he explained, had been due to an unprecedented drought, like that which affected the North of Scotland Hydro-Electric Board in the summer of 1955. Continuing his analogy, he likened the income levels, which had grown in recent years but not as steeply as one would wish, to the rise in the output of electricity, which had also grown appreciably but not sufficiently. The maximum demand was 9·5 MW in 1946, 16·5 MW in 1950, and is now 35 MW. Of this power 24 MW are consumed in Colombo, although the main generating source is situated in the hills 55 miles away.

Mr. Fernando then considered the desirability of utilizing electric power in many industries, particularly those dealing with tea, plumbago, coconuts and rice. At present the major portion of the industrial load in the hill country is powered by imported Diesel oil. A further saving in foreign exchange could be effected in traction, by electrifying the railways, and the suburban lines and omnibus services in Colombo. He estimated that the authorities could produce the electric power required for all these changes by 1964. A capital investment of Rs. 525 million would be necessary, but the saving on fuel alone would repay the interest on this sum, estimated at 3½%. Of new industries, Mr. Fernando said that the steel mill, the cement factory and the fertilizer project by themselves would require 70 million units of electricity per annum, and suggested that it would be worth while to introduce another new industry—that of manufacturing electric light bulbs, the imports of which in 1954 totalled 3·3 million bulbs, a figure which would be trebled by 1967.

Turning to the subject of small industries in Asia, he said, 'Rural industry in all Asian countries also offers a wide scope for development. At present, primitive and inefficient techniques of production result in low levels of output and long hours of work. This is the principal cause of the decay of indigenous arts and crafts. If they

are to survive and make any significant contribution to economic development, a well-planned consistent revolution in techniques of manufacture is essential. A large number of operations at present done by hand can and should be executed by power-operated machines. The Electrical Department is collaborating with the Economic Commission for Asia and the Far East in proposals now under consideration for improving such industries as the making of silverware, brassware and coir products. In Japan, where small-scale industry has achieved notable success, out of a total of 100 388 workshops employing more than five and less than fifty workers, 89 859 are based on the use of power-driven machinery.'

The future development of power supply will be by the exploitation of Ceylon's rivers (estimated to yield a power of 500–1 000 MW), in conjunction with thermal backing, and by the end of 1967 the total capacity of the island will have expanded to 255 MW. Extensive transmission and distribution systems have been planned; the national Grid will ultimately operate on 132 kV, with subsidiary distribution on 66, 33 and 11 kV.

Mr. Fernando ended with a plea that local engineering firms should undertake the training of apprentices, to supplement the output of engineers from the university and the technical college. He also emphasized the need for firms to increase their capacity for undertaking new work, and stressed the importance of the standardization of equipment.

BAGHDAD

IRAQ AND PERSIAN GULF JOINT OVERSEA GROUP

The Iraq and Persian Gulf Joint Oversea Group held its Annual General Meeting on the 22nd March at the premises of the Iraqi Engineering Society in Baghdad. The retiring Chairman, Mr. Niazi Fetto, spoke of the solid achievement of the Group, and thanked those hard-worked engineers who had yet managed to prepare and read papers. He expressed particular thanks to the retiring Secretary, Mrs. B. Shearman, and welcomed the new Chairman and Committee.

An account of the Wadi Tharthar flood-control scheme was given by Mr. F. S. Maconachie. He explained how the Tigris Barrage had been constructed at the side of the river, and told of the difficult operation of filling in the closing banks to divert the river through it. A regulator had been built alongside the barrage, and it controlled the entrance to a channel about 30 miles long between an artificial bund and a natural rise in the ground. Through this regulator the waters of the Tigris could be diverted into a vast natural depression in the desert, thus removing the annual menace of floods from lands south of Samarra. Mr. Maconachie showed a number of colour slides of various stages in the construction of the barrage, regulator and closing banks.

Sayid Mahmoud Hassan Juma, Assistant Director of Irrigation for Iraq, then gave a talk on the 'Nagara' phenomenon of the Euphrates River. This phenomenon, resulting from differences of water level in channels through marsh land, caused back-flow in some branches of the river and sudden erosions of the river bed, with consequent damage to much agricultural land. Sayid Mahmoud Hassan gave an account of early attempts to control the 'Nagara', and of their somewhat unpredictable consequences, and ended by explaining how the 'Nagara' had, in recent years, been harnessed to clear river channels which had silted up, an interesting example of how science can be used to turn a menace to advantage.

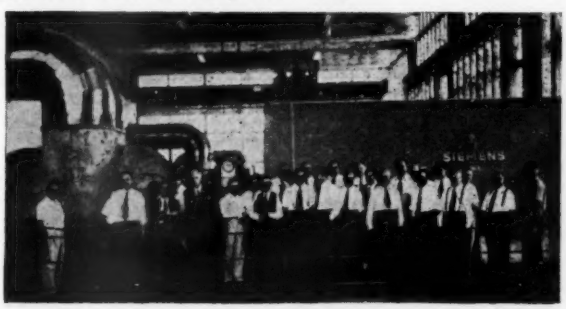
On the 23rd March members visited Samarra to see the Wadi Tharthar headworks, which have cost some £16 million and which were opened by King Feisal of Iraq a few days later. Mr. Maconachie's staff conducted small parties of members round the site and explained the operation of the various components of the headworks. Refreshments were very kindly provided by the contractors, Messrs. E. D. Zublin. In the afternoon some members visited the town of Samarra, a Moslem place of pilgrimage having a fine mosque with a golden dome, and went on to the ruins of the early Abbasid Friday Mosque, whose minaret, built with an external spiral staircase on the plan of Babylonian ziggurats, is a well-known landmark and antiquity. B. S.

ARGENTINA

ARGENTINA JOINT OVERSEA GROUP

Thirty members of the Argentina Joint Oversea Group recently visited the new power station at San Nicolás, Province of Buenos Aires. The station contains four steam turbines each of 75 000 kW, which use highly superheated steam at 1 500 lb/inch^2 pressure. All who attended expressed their satisfaction with the excursion.

Members at San Nicolás power station



OVERSEA ATTENDANCE REGISTER

During the period 1st April to 30th April, 1956, the following members called at the Institution building and signed the Attendance Register of Oversea Members:

ANGUS, J. HOUSTON (Lagos).
BALASUNDARAM, N. (Faridabad, India).
BARDENS, A. T. B. (Hong Kong).
BHATIA, H. R. (Punjab).
BONNY, A. G. A. (Pernambuco, Brazil).
BOTTOMS, R. F. (Ipoh, Malaya).
COATES, A. G. (Tripoli).
CRAMB, A. L. (New Delhi).
DRUMMOND, G. A., B.E., M.SC. (Auckland).
FELIPES, L. G. (Port-of-Spain).
FINCH, K. W., B.SC.(ENG.) (Port-of-Spain).
GHAZAROS, K. (Khartoum).
HAYES, L. W., O.B.E. (Geneva).
JOHNSON, S. C. (Kobe, Japan).
KORAM, E. M., B.SC.(ENG.) (Accra).
NADKARNI, P. S. (Poona).
SIDDAWAY, T. (Singapore).
SUTHERLAND, S. H. J. (Tema, Gold Coast).
WHETTON, D. S. (Bulawayo).

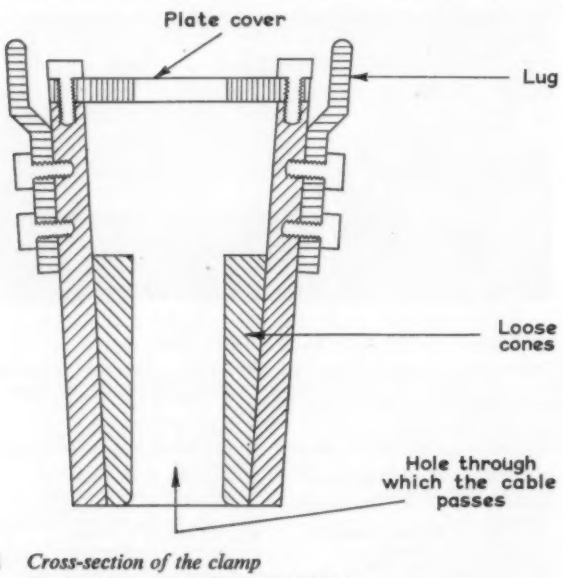
A Recovery Clamp for Raising Underwater Cables

By **J. PARKER**

Engineers in the remoter parts of the world frequently encounter problems which do not face their colleagues in more industrialized countries. This article describes how such a problem was solved by a simple and ingenious invention. The author is with the E.A. Power and Lighting Co., Mombasa.

OWING to the breakdown of two 10 kV submarine cables laid in sea-water varying in depth from 2 to 23 fathoms between an island and the mainland of East Africa, it was decided to lay a standard underground cable temporarily, in view of the loss in revenue and the penalty clause within the supply agreement, coupled with the fact that the delivery and installation of replacement submarine cables covered a period of six months.

After the two replacement cables had been laid preparations were made for the recovery of the underground cable and the two faulty submarine cables. The latter were to be recovered for their scrap value at the same time as the underground cable, which it was hoped would not have suffered from its immersion. The cost of hiring a suitable craft was high, and if a loss was not to be incurred on the salvage operation it was necessary that the underground cable should be recovered in good condition.



1 *Cross-section of the clamp*
The height of the clamp is about 14 inches.

2 *The clamp threaded over the cable*

In order to carry out the operation a recovery clamp was designed, as shown in Fig. 1. It was fastened to a steel hawser which passed over the bows of the ship to the ship's winch. The clamp was threaded over the cable as in Fig. 2 and allowed to slide down it to the sea bed. On raising the clamp the loose cones gripped the cable, so that its weight was taken at a point as near to the sea bed as possible. Each lift recovered the length of cable corresponding to the depth of water in which it was lying, and the cable was then manhandled into the ship's hold and coiled on a drum. The weight of the clamp (95lb) removed all slight sea growths as it slid down the cable. It was necessary to provide rope stoppers at each lift but no difficulty was experienced other than occasional jamming of the centre cones through a tear in the jute serving, caused during the laying of the cable. Even on those few occasions a sharp blow on the top of the cone was all that was necessary to free it.

The use of the clamp proved to be entirely satisfactory, and in fact made the recovery of the cable worth while.

OBITUARY

HARRY ALLCOCK

Harry Allcock, who died on the 21st January, 1956, was born in 1879. He was educated at Hulme Grammar School and in 1895 entered a four-year apprenticeship with Royce Ltd., of Manchester, where as one of the first apprentices to be trained by Sir Henry Royce, he gained experience in the manufacture and maintenance of all kinds of electrical plant, including dynamos, motors, arc lamps and instruments. During his apprenticeship he attended classes at the Manchester Technical School in mathematics, mechanics and electricity.

In 1899 he joined Trafford Power and Light Supply Ltd. as Electrical Engineer, with the responsibility for all generating recording and distributing plant. Three years later he was appointed Estimating Engineer with W. T. Glover and Co., of Trafford Park, with whom he stayed until his retirement in 1950. In 1904 he went to South Africa as the firm's Resident Manager, and later he became the firm's technical and commercial expert, in which capacity he travelled extensively to many parts of the world.

For more than thirty years he was a director of the Manchester Chamber of Commerce, and at various times he also served as Vice-President of the British Engineers' Association, as a vice-president, member of the Grand Council and Chairman of the north-western region of the Federation of British Industries, as a member of the executive council of the Association of British Chambers of Commerce and as Chairman of the executive council of the Decimal Association. He was also a freemason, and in his leisure time a keen golfer. He leaves two sons and six grandchildren.

Mr. Allcock joined The Institution as an Associate in 1901, and was elected an Associate Member in 1904 and a Member in 1912. He was also a member of The Institution of Mechanical Engineers and a member of the American Institute of Electrical Engineers.

M. D. D.

EDWARD STANLEY BYNG

Edward Stanley Byng, who died on the 13th January, 1956, was born at Derby on the 4th August, 1883. He was educated at a private school in Derby and at Derby Technical College, and obtained practical experience at the Sheffield power station of the Midland Railway Co. in 1903–04.

Joining the National Telephone Co. in 1904, he shortly became Assistant Engineer in charge of overhead and underground telephone construction and maintenance for Sheffield and district, and was promoted to Sub-Engineer in 1906. During these years in Sheffield he attended evening courses at Sheffield University in electrical, mechanical and civil engineering. In 1909 he was transferred to London, where, a year later, he was appointed Design Engineer, and later still Sectional Officer for the company's underground development schemes. When the company was taken over by the State in 1912 he joined the staff of the Post Office Engineering Department as Design Engineer dealing with plant studies and estimates.

In 1913 he joined the Western Electric Co. (now Standard Telephones and Cables, Ltd.) as Engineer in charge of telephone cable contracts. During the First World War he was particularly concerned with telephone installations for munitions factories. In 1917 he took charge of naval hydrophone installations at Portsmouth and Portland dockyards, and was loaned to the Admiralty for special services at home and abroad as technical adviser on submarine detection. In the Second World War he again rendered assistance to the Admiralty, serving, between 1943 and 1945, on three committees concerned with the organization of naval departments.

With the International Standard Electric Corporation from 1921 to 1928, latterly as European Director of Installations, he was responsible for a number of important trunk telephone cable installations on the Continent. In 1928 he was appointed Managing Director of Standard Telephones and Cables, Ltd., and became Vice-Chairman in 1933.

Mr. Byng was one of the earliest advocates of a broader education for the professional engineer, and took a keen interest in the various organizations dealing with administration, management, education, industrial psychology and similar subjects. A founder member of the British Institute of Management, he had served as a Vice-President of the Institute of Industrial Administration, Vice-Chairman of the National Institute of Industrial Psychology and Vice-Chairman of the British Association for Commercial and Industrial Education. He took an active part in the Industrial Management Research Association and served on the advisory committee for commerce, business administration and engineering of the Regent Street Polytechnic. He was once Chairman of the Telephone Development Association.

He was also a member of a number of Government committees, and served from 1947 onwards on the Ministry of Education's Central Advisory Council for England. In 1943 he was Chairman of the Ministry of Labour's London Regional Advisory Council for Juvenile Employment. He also served as Deputy-Chairman of the Postal and Telecommunications Advisory Committee of the London Chamber of Commerce, and was a member of the Education Committee, and a former member of the Grand Council, of the Federation of British Industries.

Mr. Byng joined The Institution as a Student in 1907, and was elected an Associate Member in 1909, and a Member in 1920. He was a Member of Council from 1935 to 1942, and Honorary Treasurer from 1943 to 1946. He also served The Institution on a number of committees including the Finance Committee, the Education and Examinations Committee, the Membership Committee, the Telegraph and Telephones Technical Committee and the Benevolent Fund Committee. He acted, too, as Chairman of the Joint Committee on National Certificates in Electrical Engineering.

He was the author of a number of papers on administrative subjects, and lectured widely on engineering economics. For his paper 'Telephone Line Work in the United States', presented to The Institution in 1921, he was awarded the Fahie Premium in 1922. His wide administrative experience formed the background to his paper 'The Engineer Administrator', presented to The Institution in 1935, for which he was awarded an Extra Premium.

He was also a Fellow of the American Institute of Electrical Engineers.

T. G. S.

SAMUEL IRWIN CROOKES

Samuel Irwin Crookes, who died on the 26th December, 1955, was born on the 23rd January, 1871, in Sheffield. Educated in that city and at Sheffield and London Universities, he specialized in electrical engineering and chemistry.

Mr. Crookes's early years were spent in lecturing on electrical engineering at Battersea Polytechnic, which he left in 1907 to emigrate with his family to New Zealand. Settling in Auckland city he took charge of the physics and electrical engineering department of the Seddon Memorial Technical College, and also lectured at the Auckland University College School of Engineering.

In addition to lecturing he opened a private practice as a Consulting Engineer and played a prominent part in the design and establishment of various hydro-electric schemes. He was also prominent in the establishment of large superphosphate works in different parts of New Zealand.

He had a strong sense of civic duty and was a founder member of the Auckland Electric-Power Board, serving on that board for more than twenty-five years, for some of them as Chairman. Other local bodies which benefited from his wisdom and experience were the Auckland City Council and the Auckland Metropolitan Drainage Board.

Mr. Crookes had many and diverse activities, one of which was a lively interest in farming, particularly the breeding of Jersey cattle. He was President of the Auckland Agricultural and Pastoral Association for many years, and was also on the Board of the Massey Agricultural College. He was prominent in fertilizer research and manufacture, being one of the prime movers in the establishment of the New Zealand Fertilizer Manufacturers' Research Association, an organization sponsored by the New Zealand Government.

He was a director of a number of private companies and at the time of his death was Chairman of the New Zealand Farmers' Fertilizer Co. and Deputy-Chairman of the Kiwi Fertilizer Co.

Mr. Crookes served for many years on the Auckland University College Council, the Seddon Memorial Technical College Board of Managers and the Auckland Grammar School Board. He was a Past-President of the New Zealand Institution of Engineers, and a Past Vice-President of the Institution of Chemical Engineers, London.

He married Miss May Robinson, a daughter of Mr. Phillip Robinson, who in the late nineteenth century had an international reputation as a specialist engineer in the iron and steel industry. Mr. Crookes is survived by his widow, two sons and two daughters.

He joined The Institution as an Associate in 1899, and was elected an Associate Member in 1905 and a Member in 1910. A. O. G.

DAVID JOHNSON GADSBY

David Johnson Gadsby, who died on the 6th January, 1956, was born on the 4th August, 1874. He received his technical education at Crystal Palace school from 1891 to 1893, and his practical training with Crompton and Co., at Chelmsford, and the Chelmsford Electric Lighting Co., from 1893 to 1895. He was then appointed Chief Assistant Engineer to the Hove Electric Lighting Co. On the transference of that company to Hove Corporation in 1913 he became Deputy Engineer and Manager, and continued in that capacity until his retirement in 1919.

He was elected a member of the Hove Town Council in 1930, and became an Alderman in 1951, continuing to serve on the Council until 1955. While he had served on most of the Council committees and occupied most of the chairs with distinction, it was the cause of education to which he was most deeply attached. He was one of the ablest Chairmen of the former Hove Education Committee and his service on that committee and the committee which is now the Hove and Portslade Divisional Executive for Education extended over twenty years. He always endeavoured to do his best for the town in which he lived for seventy years. In his leisure time he was an enthusiastic member of the Brighton and Hove Philatelic Society, and arranged periodic exhibitions of stamps in the public library.

Mr. Gadsby joined The Institution as a Student in 1894, and was elected an Associate in 1896, an Associate Member in 1899 and a Member in 1905. He was also an Associate Member of The Institution of Civil Engineers. F. S.

EWART VIVIAN PERROW

Ewart Vivian Perrow, who died on the 1st May, 1955, was born on the 17th July, 1885. He was educated at St. Mary's Day School, Truro, and Truro College, attending evening classes in electrical engineering at Cornwall Central Technical Schools, Truro, during the last two years of his college course.

On completing his education at the age of seventeen, he went to South Africa, where he joined the General Electric Co. in Johannesburg for three years' apprenticeship training in electrical and mechanical engineering.

He left this company in 1906 for the gold mining industry, and was employed in turn in the electrical engineering departments of the Langlaate Estate and Gold Mining Co., Johannesburg, Geldenhuis Deep Ltd., Johannesburg, the Durban Roodepoort Deep Gold Mining Co. and the Consolidated Main Reef Mines and Estates Gold Mining Co. At this time the gold mining industry was just beginning to realize the need for electrical equipment.

In 1922 Mr. Perrow left the Witwatersrand for Northern Rhodesia having been appointed Electrical Engineer of the Rhodesia Broken Hill Development Co., and in 1924 he became Resident Engineer of the mine. During this period the Mulungushi hydro-electric scheme for supplying power to the Broken Hill mine was under construction.

In 1926 Mr. Perrow returned to Johannesburg where he held important appointments with Hubert Davies and Co. and G. H. Langler and Co. From 1937 to the time of his death he was with Stratford Engineering Ltd., in control of Technical Sales and Maintenance. A particular interest was the Vulcan Sinclair Fluidrive fluid coupling, and he gave much of his time and energy to the introduction of this equipment.

Mr. Perrow always took great interest in the activities of the engineering societies of the country of his adoption, and was a founder member, President (1922) and Honorary Member (1952) of the South African Institute of Electrical Engineers, and was for a number of years a member of the Commission of Examiners for the Government Certificate of Competency. He was also Chairman of the Safety Precautions Committee, which has been instrumental in reducing the number of accidents arising from electrical installations in mines and industry generally.

Vivian Perrow has left a wide circle of friends and colleagues in the Union and the Rhodesias to mourn his passing. He is survived by a daughter and two sons.

He joined The Institution as an Associate Member in 1920 and was elected a Member in 1945. A. W. L.

FELIX JOHN CLEWETT POLE

Sir Felix John Clewett Pole, who died on the 15th January, 1956, was born on the 1st February, 1877. He was the son of a Wiltshire village schoolmaster, who was an accomplished mathematician, naturalist and fisherman, and of whom the vicar of Little Bedwyn said, '. . . a man so universally loved and respected . . . a strong man . . . tender hearted (with) affection that was very real and deep in a heart mellowed by human and wide experience'.

Felix Pole inherited conspicuously his father's strength of character, human kindness and love of nature. He thrust himself into wide experience, welcomed responsibility and attracted loyalty—a generous and kindly man who never lost 'the common touch'.

He went to school at Ramsbury, Wilts, and commenced work with the Great Western Railway at the age of fourteen in the telegraph office at Swindon. At the age of forty-four he was General Manager. For eight years he managed the railway most ably, zealously inspiring the family spirit and actively developing all the human, technical and commercial aspects of the great undertaking. 'Pole of Paddington' was as respected in the board room as he was amongst the station masters and porters right down the line—to whom he always enjoyed making himself known, with a flair for friendship without sacrifice of dignity.

He gave much of his time to extraneous work, visiting the Sudan in 1923 and 1930 to report on transport there; he served on very many Government and industrial committees concerned with subjects ranging from pensions to research. He was knighted in 1924.

In 1929 he left the G.W.R. to become Chairman of Associated Electrical Industries Ltd., a concern which at that time had recently embraced ownership of a group of manufacturing companies of which British Thomson-Houston and Metropolitan-Vickers were the principals. These were proud and powerful companies, accustomed to stern competition with each other. There were naturally years with technical and commercial conflict in the background, during which important officials in the respective camps held divergent views. Here Sir Felix's wise and kindly genius and his ability to bring opposite numbers together in friendly co-operation was exercised with irresistible persistence. Without his incorrigible and often embarrassing unconventionality which took him into the offices, works and canteens to talk with office boys, workers, engineers and managers (more than twenty-five years ago this was a most unusual habit for a Chairman) the union of the several erstwhile independent organizations would have been effected even less smoothly.

Sir Felix from earliest days always wanted young fellows to have an unobstructed chance to advance; shop boys and apprentices, if they had it in them, could win directorships. He had a pioneering insistence on the duty of an employer to provide for pensions for employees, and thousands of people are grateful to him for that. He was always willingly at the call of all movements and associations in the electrical world, to support them by attendance and by speaking at their functions; a genial personality with the desire and the power to assist.

He relinquished the chairmanship of A.E.I. in 1945, although he remained a director until last year, for it was in 1945 that the great tragedy of his life had begun; his eyesight failed, and a year later he was quite blind. After many discouraging surgical operations, in a subsequent decade of darkness his natural courage and cleverness shone forth. Brushing aside his handicap and all sympathetic condolences, he continued active direction in several important concerns, continued to write by hand to his friends, mastered Braille, and in his presence it was always difficult to remember his blindness.

He probably missed his enjoyment as an accomplished fisherman and enthusiastic naturalist—both inherited from his father—more than he did unhampered continuation of his work as a great railwayman and a great industrialist. But he retained enjoyment in all he did, was as always fearless, generous and kind. As for his friends and colleagues, their affection outweighs even their admiration.

Sir Felix Pole joined The Institution as a Companion in 1938. H. W.

FRANK WHIPP

Frank Whipp, who died on the 14th January, 1956, was born on the 30th July, 1885. After being educated at Rochdale Collegiate School and at Ashville College, Harrogate, he entered the firm of Bertram Thomas Ltd., Manchester, where he received his early training in electrical engineering. While with this firm he continued his studies by means of a correspondence course. In 1905 he became associated with his brother, the late Mr. Samuel Whipp, and the late Mr. Charles Bourne in the firm of Whipp and Bourne, Electrical Engineers, first in Rochdale, and later at the present works in Castleton.

On the formation of Whipp and Bourne Ltd. in 1915, Mr. Whipp was made joint Managing Director, being elected Chairman of the company in 1951.

Throughout his long association with the company he displayed great skill and ingenuity in the many fields of manufacture in which the company was interested, particularly in his work for the Admiralty and mercantile marine. He was always striving for the very best, both in design and manufacture, and instilled into his staff a sense of pride in the company's achievements.

His hobbies were fishing and shooting and he indulged in them keenly, being a member of the Yorkshire Anglers Association up to the time of his death. Whether at work or play, he never spared himself, and was approachable at all times by all who knew him. He is survived by his widow, two sons and a daughter, having lost his eldest son in a shooting accident twelve months ago.

Mr. Whipp joined The Institution as a Member in 1918. H. H.

WILLIAM SMITH WILSON

William Smith Wilson, who died on the 16th October, 1955, was born on the 20th September, 1876, at Jarrow, Co. Durham, where his father was Shipyard Manager of the old Palmers Shipbuilding and Iron Co. He was educated at Blairlodge School, Edinburgh, and Armstrong College, although part of his childhood was spent in Spain, and obtained practical experience with the Hampstead Electric

Light and Battery Co., and with John Brown and Co., Clydebank. From 1901 to 1910 he was employed as a draughtsman with Clarke Chapman and Co., of Gateshead, where he gained experience of electrical work of all descriptions, including the installation of electric light and power in all classes of ships for the Royal Navy and the mercantile marine. In 1911 he joined Johnson and Phillips Ltd., cable manufacturers, as Branch Manager at Newcastle upon Tyne, and was eventually placed in charge of their marine sales department for the whole country.

Throughout the whole of the First World War Mr. Wilson served in the Royal Engineers, and in 1919 he rejoined his old firm.

In addition to his managerial duties he was the north-east coast correspondent for the *Shipping World* from 1933 to 1952. For many years he was a member of the North-East Coast Institution of Engineers and Shipbuilders, and served on the Council of that body. He was keenly interested in gardening and amateur dramatics and was a member of the old Newcastle repertory company from 1924 to 1932.

Mr. Wilson joined The Institution as an Associate Member in 1913 and was elected a Member in 1922. G. M. M.

CORRESPONDENCE

ALUMINIUM MELTING FURNACES

From S. A. VINCZE, DIPL. ING., MEMBER

General

Two identical fully automatic melting furnaces for aluminium have been designed and built in New Zealand for the following duty:

(*a*) To heat 175 lb of aluminium from 575° C to 800° C in 1 hour. (The melting-point of aluminium is about 658° C.)

(*b*) To raise the temperature of the furnace and of the charge to 575° C from cold.

Since (*a*) is the more onerous duty, no time limit has been specified for carrying out (*b*).

The empty weight of the melting-pot, which is made of a special cast-iron alloy, is about 123 lb.

Thermal Calculations

Calculations on various heat-resisting insulating materials whose thermal conductivity ranges from 0·0126 to 0·00144 watt/cm-°C, with various thicknesses of the heat insulation between 10 and 30·5 cm, showed that the power requirement per furnace would be in the range 33·6–18·3 kW, depending on the material used and on the construction employed.

A cylindrical steel-shell construction has been adopted with layers of plastic refractory cement and granulated vermiculite insulation, both layers being 7·6 cm thick. The former's thermal conductivity is 0·00865 watt/cm-°C, the latter's 0·00144 watt/cm-°C, both being measured at 850° C.

Furnace Transformers

A 30 kVA 400/65-volt 50 c/s oil-immersed continuously-rated delta-delta-connected 3-phase transformer, made to the specification of B.S. 171: 1936, has been provided for each furnace, with 400, 420, 440, 460, and 480-volt primary taps and off-load tap-changing gear on the 400-volt side, to give 65, 62, 59, 56·5, and 54 volts on the secondary side when the primary is fed with 400 volts. The corresponding outputs are 30, 27, 24·8, 22·6 and 20·6 kVA. In addition the primary winding has all six terminals brought out to enable delta-star control on load.

Furnace Construction

The 3-phase heating element consists of 0·75 inch × 0·07 inch strips of 80/20 Nichrome alloy. They are evenly distributed around the melting-pot—not unlike the stator winding of a 3-phase induction motor—suspended on heat-resisting unglazed porcelain insulating spools which are held by 80/20 Nichrome pins. The heating elements are permanently connected in delta. The terminals are made of 0·5-inch-diameter rods of the same material and are welded to the resistor strips inside the furnace; they are provided with 0·5-inch B.S.F. threads and hexagonal nuts outside the furnace. They are carried through the furnace walls in heat-resisting porcelain bushings. Spools and bushings have been specified for 1 000° C working temperature.

Furnace Control

Each furnace is permanently connected with the secondary windings of its respective transformer by means of Pyrotenax cables. It has its own independent contactor-type control gear mounted, together with the supervisory instruments, on a dead-front-type steel control panel, which also has been completely designed and assembled in New Zealand.

One chopping-bar-type thermo-electric pyrometer and temperature governor, 0–1 000° C range, for automatic delta-star control, 3 quadrant-type ammeters (overload type), 1 quadrant voltmeter with a 7-position voltmeter switch, 1 kilowatt-hour meter and 2 time switches are provided for each furnace. All electrical measuring instruments are connected on the 400-volt side of the transformer.

The control gear is suitable for either fully automatic or hand operation and works as follows:

Fully Automatic Operation. Each transformer-furnace group can be entirely isolated by its hand-operated main switch. When the latter is on, but the furnace off, a green signal lamp lights. The furnace and furnace transformer are controlled as one unit and both are either on or off together. They are switched on by the time switches, as a rule in the early morning, and started in delta

Mr. Vincze is a consultant.

(full power). When the furnace and furnace transformer are on the signal light shows red.

After the selected temperature, which may be any value between 100 and 1 000° C, has been reached, the furnace transformer will be automatically switched into star-connection (one-third full power) and the temperature kept 'constant' at the selected temperature (±20° C) by automatic on-off control of the star contactor.

Should the temperature rise much above the selected value for any reason, e.g. sticking of the star or of the delta contactor, the furnace will be automatically disconnected by the line contactor and the alarm given. The same will happen should the temperature controller (governor) fail, perhaps owing to the pyrometer thermocouple burning out. The alarm bell can be switched off by hand, but the orange emergency lamp will keep on burning as long as the pointer of the temperature controller remains in the alarm position.

Normal closing down of the plant at the end of the working day is initiated automatically by the time switch.

Hand Operation. For hand operation, the selector switch is brought into the 'hand' position. A hand-operated pilot switch enables on-load switching of the furnace transformer into delta or star-connection at will, whereas another hand-operated pilot switch serves for on-off control. When on hand control, the temperature governor will act as an indicating pyrometer only, but the excess temperature and thermocouple failure alarms are still available as above. However no automatic disconnection of the furnaces takes place in hand operation.

Temperature Recording

A synchronous motor-driven chopper-bar-type two-colour temperature recorder and direct-reading pyrometer is also provided for the two furnaces. The range of the instrument is 0–1 000° C, the chart feed being 20 mm/hour. A special recording panel is provided between the two control boards for this instrument.

Operating Experience

The furnaces were commissioned in December, 1954, and have been in commercial operation ever since. There have been no initial troubles with the electrical plant.

Some minor mechanical difficulty has occurred—e.g. cracking of the refractory liner, growth of the cast-iron melting-pot, and the lining of the latter proving not quite satisfactory; but it is understood that these have been or are being overcome.

The heat insulation of the furnaces has proved very satisfactory. The outside temperature of the furnace shell does not exceed 80–84° C with the melting-pot at 900° C. This compares favourably with the old oil-fired furnaces of the same establishment, which exhibit outside furnace temperatures of about 180° C under similar melting-pot temperatures.

Acknowledgments

The writer wishes to thank Mr. K. Pallo, Governing Director, Die Castings Ltd., of Lower Hutt, New Zealand, for the opportunity to carry out this work, his assistance over it, and his permission to publish this letter.

Annual Dinner of the Admiralty Electrical Engineering Officers

On the 20th March, 1956, the Admiralty Electrical Engineering Officers held their annual dinner in Bath, under the chairmanship of Sir Hamish D. MacLaren, a Vice-President of The Institution and Director of Electrical Engineering, Admiralty. The assembled company of 225 included the Vice-Controller of the Navy, Rear-Admiral G. B. Sayer, the heads of several Admiralty departments, some 60 guests from the electrical manufacturing and the shipbuilding industries, and members of the civilian and naval staff of the Department of Electrical Engineering, including the Royal Dockyards.

The Institution was represented, in addition to Sir Hamish, by Mr. T. G. Dash, Chairman of the Western Centre. Rear-Admiral P. W. Snyder (U.S. Navy Shipbuilding Representative Europe) and the Assistant Naval Attaché to the American Embassy, Cmdr. D. Furlong, represented the U.S. Navy.

The principal speaker was Major C. A. J. Martin and in his speech he commended the Admiralty electrical officers for the skill and ability with which they tackled a very wide field of technical problems—made very much more difficult by the extreme conditions in which much naval equipment had sometimes to operate.

In his reply Sir Hamish MacLaren referred to his recent visit to the United States and particularly emphasized the lead the Americans had taken by their rapid development and quantity production of cables using silicone-compounded insulants, an example which he hoped would be followed by cable makers in this country.

A group photographed at the dinner

Left to right: F. N. Smith; Rear-Admiral G. B. Sayer; Sir Hamish MacLaren, Chartered Electrical Engineer; Rear-Admiral P. W. Snyder, U.S.N.; Major C. A. J. Martin, Chartered Electrical Engineer; W. M. Couch, Chartered Electrical Engineer.

TECHNICAL PUBLICATIONS

BRITISH STANDARDS AND CODES OF PRACTICE

The Secretary has been asked to draw attention to the following publications, copies of which can be obtained from the British Standards Institution, 2 Park Street, London, W.1. The prices given are post free.

Outline Dimensions for Electric Lifts (B.S. 2655. Part 3: 1955). 3s.

This Standard gives outline dimensions for the installation of six classes of electric lift: light-traffic passenger lifts, general-purpose passenger lifts, intensive-traffic passenger lifts, hospital bed/passenger lifts, general-duty goods lifts and heavy-duty goods lifts. The dimensions result from a detailed study of the accepted practice that has developed in this country over a number of years: the standards of other countries, including the United States, have also been taken into account.

Guide to Terms used in A.C. Power System Studies (B.S. 2658: 1956). 6s.

Power-system engineers and designers of electrical generating machinery have in the past been hindered by the lack of uniformity of the terms, and their meanings, used in their work. The problem has extended to the teaching profession and to writers of technical papers.

This guide was prepared by the Electrical Research Association and remedies the situation by defining the terms in most common use. Since the publication is intended as a guide rather than merely as a glossary, the definitions and explanations have been made more detailed and descriptive than is usual in a glossary. Letter symbols for many quantities appear in the text and are collected for reference after the list of contents.

Recommended Methods for Estimating the Effect of Deleterious Substances in Fibrous Electrical Insulating Materials (B.S. 2689: 1956). 4s.

This Standard describes reference test methods for the estimation of certain deleterious substances which may be present in fibrous electrical insulating materials. Methods are given for assessing the effect of deleterious substances when the insulating materials are subjected to a specified heat-ageing treatment.

Fuses for Alternating Current Circuits above 660 Volts (B.S. 2692: 1956). 10s.

The fuses, with current ratings up to 200 amp, are for use on a.c. circuits where the rated voltage is higher than 660 volts. Current ratings for fuses for voltage transformers are given separately. Breaking-capacity ratings are given only for voltage ratings up to 66 kV.

The Electrical Performance of Semi-Conductor Rectifiers (Metal Rectifiers) (B.S. 2709: 1956). 2s. 6d.

This Standard deals with individual semi-conductor rectifier elements and stacks which are for use when d.c. power is required from an a.c. source, the frequency of which does not exceed 20 kc/s. It describes the basis of the rating, and states the cooling conditions envisaged. It also specifies type and routine production tests, and gives terminal and other identification markings. Various methods of connection are given and are illustrated by Figures.

Code of Practice for Street Lighting. Part 2. Roads other than Traffic Routes (CP 1004. Part 2: 1956). 3s. 6d.

The Code was drafted by a Joint Committee of The Institution and the B.S.I., and is designed to develop the recommendations made in the final report of the Ministry of Transport Departmental Committee on Street Lighting (H.M.S.O. 1937). The second part, now issued on the authority of the Council for Codes of Practice, deals with roads other than traffic routes, i.e. with roads classed as Group B in the report. Part 1, dealing with traffic routes, was published in 1952.

Consideration is given to the allowances to be made when the lighting of a given road is planned, e.g. volume and type of traffic, layout and nature of road, boundary conditions, presence of obstructions, etc. Recommendations are made, for various circumstances, on the choice of light distribution and on the spacing of lanterns. The use of either electricity or gas is envisaged, but electrical and gas installation practice is outside the scope of the Code.

E.R.A. REPORTS

The Secretary has been asked to draw attention to the undermentioned E.R.A. Reports. Copies can be obtained from the British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. The price of each report is given, and, unless otherwise stated, the cost of postage on a report is 3d.

NT/71. **A Study of Domain Structures in Alnico** by L. F. Bates and D. H. Martin. 7s. 6d. (postage 4d.).

It is well known that Alnico (Al 10%, Ni 18%, Co 12%, Cu 6%, Fe 54%), when quenched from 1 250° C in water and subsequently annealed at 600° C, develops pronounced permanent-magnet properties. The effect is due to the precipitation of a metallurgical phase in the form of submicroscopic islands. The present paper records a powder deposit examination of the ferromagnetic domain structures in four specimens of Alnico. Patterns are formed on highly polished surfaces by fine magnetic powders deposited from colloidal suspensions, and when interpreted indicate the form of the underlying domain structure.

Q/T140. **Iron-Loss Tests on Transformers with Cores of Hot-Rolled and Cold-Rolled Silicon Steel.** 7s. 6d.

It has often been assumed that anisotropic (cold-rolled) transformer steel can be successfully used only if special types of core are employed, but there has been no published information as to the results which could be obtained using orthodox cores with ordinary interleaved joints. It was decided therefore to carry out tests on three 3-phase 100 kVA transformers of

a design standard to one manufacturer, and with cores made up of ordinary hot-rolled silicon steel, cold-rolled silicon steel of British manufacture, and cold-rolled silicon steel of American manufacture.

Q/T141. **An Adjustable Ambient-Temperature Thermometer for use when Testing Transformers** by M. R. Dickson. 12s. 6D.

Details are given of a simple device for use when air-cooled transformers are tested, which determines the effective cooling-air temperature, taking into account any temperature variations that may have occurred previous to the time of reading. Adjustment is provided so that the device may be used with a wide range of transformer types and sizes.

V/T125. **A Stable Synchronous Detector for Audio-Frequency Measurements** by P. G. Kendall. 12s. 6D. (POSTAGE 4D.).

The report describes the design and performance of a synchronous detector which was developed especially for the measuring system of the E.R.A. network analyser. In this system the detector is used in servo-operated a.c. potentiometers and in electronic wattmeters. The design has to satisfy stringent conditions of accuracy and stability over a frequency range of 100 c/s to 16 kc/s but is otherwise not specialized and may be used in a variety of electronic measuring systems.

V/T127. **A.C. Network Analysers. Relation between System and Analyser Quantities for Single-Frequency and Broad-Band Studies** by A. P. N. Ford and J. Miedzinski. 10s. 6D. (POSTAGE 4D.).

Before an electric network can be studied on a network analyser, the original data on component values and operating levels must be converted to the percentage (or *per unit*) form in which the analyser dials are marked. The final results of a study are usually converted back to the original form, but knowledge of the correlation between the system quantities and their representation on the analyser can assist the clients (i.e. the originators of the problem) in the interpretation of the analyser setting-up diagrams and intermediate results. This is particularly important in more complicated problems where a great deal of consultation must take place between the clients and the analyser staff.

Z/T100. **Atmospheric Freezing, Pulsations and Evolutionary Progression in the Long-Period Variable Stars** by C. E. R. Bruce. 4s. 6D. (POSTAGE 4D.).

It is suggested that electrical-charge separation may be caused in stellar atmospheres by the freezing out of different materials, just as the separation of charges in thunderclouds is associated with the freezing of water. The electrical discharges resulting from the charge separation offer an explanation for the pulsations of long-period variable stars and their irregularity, and for the appearance of the bright lines in their spectra.

Z/T104. **Argon Arc Welding of Aluminium and its Alloys. Electrical Considerations** by L. H. Orton and J. C. Needham. 15s. (POSTAGE 4D.).

This report deals with the electrical characteristics of both arc and power circuit necessary for adequate arc stability to promote high-quality welding. Conventional power plant, used for example for the metallic-arc welding of mild steel, is not in itself suitable for argon-arc welding, and additional electrical equipment or specially designed composite plant is required.

H.M. TREASURY

The Institution's Library has received copies of the following two publications that should appeal to many members, especially those who are directly concerned with office organization. Both are official Treasury productions, and are directed mainly towards the improvement of office methods and procedure. They are therefore particularly relevant to administrative bodies and commercial firms, but many ideas in them are also applicable generally to public bodies or private firms where the main activity is not work in offices.

Those to whom the phrase 'O and M' is new may look for some explanation; people often wrongfully interpret it as being connected with 'office manager', 'office machines' and even (in the Civil Service, where it originated) with 'officious and meddlesome'. In fact it denotes 'Organization and Methods', a title now widely (though not universally) used to describe the study, by whole-time staff, of the organization of public bodies or private firms, and of the office procedures they adopt.

Organization is used (either with an 'O' for higher organization or with an 'o' for office organization) to cover the division of duties between office workers. The word 'method' is used to cover any office process, mechanical or manual, and of course the various designs of forms, furniture and equipment, employed to improve the flow of work.

1. The Practice of O & M (H.M.S.O.). 5s.

This is a short book of some 45 pages, essentially written in a common-sense way and therefore easy to read. In effect it is a manual for frequent reference and use by those engaged on improving the efficiency and productivity of the office. The book is addressed to those who are full-time on the job, as a guide to their work in making investigations of clerical work or machine processes, but it is obviously very usable by part-timers also.

The material is good and has been skilfully arranged and worded. The author comprehends the value of short words, short sentences, and short paragraphs. He includes plenty of sound practical advice. After a brief introduction the manual sets out ways of planning an assignment, conducting inquiries, forming conclusions, reporting on conclusions and following up during and after the installation of new methods. The appendices are particularly useful and contain notes on points and questions for the preliminary survey; questions for organization analysis and procedure analysis; reasons for excessive paper work; causes and effects of faulty organization; and format for reports.

The usefulness of the book would have been enhanced by a few case-histories of actual assignments carried out by O and M officers. Despite the author's wholly unpadded style, one cannot escape the feeling at times—as in so many books on administration—that one is reading truisms, and one itches to see the deployment of strategical and tactical advice in a practical operation. Possibly, because the book stems from a Government department, such illustration would have been difficult to arrange without concealing identities so thoroughly as to deprive the case-histories of nearly all their value. A second slight criticism is that the book lacks an index; no technical book, however short, should be produced without one.

2. The O & M Bulletin. Published bi-monthly by the Organization and Methods Division of H.M. Treasury. 10s. per annum.

Through the courtesy of the Director of Organization and

Methods of H.M. Treasury, The Institution now receives copies of this periodical. It makes a practical contribution to office management and the articles are concerned with actual organizations, office procedures, methods, office machines and labour-saving devices. The contents are not confined to office work in Government departments for there are valuable contributions from authors in large industrial firms, on, e.g., visual stock control, simplified procedures, and work measurement. Electrical engineers, and especially those concerned with explaining new electrical developments to laymen, will be interested in two recent articles on electronic computers published in the *O & M Bulletin*. The first of these puts into very simple language the general knowledge that the executive needs when faced with a complicated and perhaps highly technical account of new office machinery. The second article describes the purposes for which such machines have so far been installed in the Government service and refers to forthcoming publications on their application.

We are advised by the Editor of the *O & M Bulletin* that it is issued primarily for official use and that as an official document it should be regarded by other subscribers as intended for their personal use only. Companies who are interested may apply to the Director of O & M at the Treasury for subscription order forms.

MONOGRAPHS AND PAPERS
published individually this month

Monograph, Individual Paper and Reprint Service

Synopses of monographs and papers published individually before the next issue of the Journal are given below, and, unless otherwise stated, their dates of publication are this month. Reprints of all papers are available about two months after publication in the Proceedings. The prices shown below are post free. When ordering please quote serial number of paper or monograph. Books of 8 vouchers may be obtained from the Secretary, price 10s. each.

	PAPER FOR READING	PAPER FOR PUBLICATION ONLY	MONOGRAPH
More than 10 days before first reading (if published early) ..	2s. 6d.[1]	—	1s. 3d. (From date of individual publication, including period after republication in the *Proceedings*)
Period of 10 days before first reading	Free[2]	—	
Period between first reading and republication in the *Proceedings*	Free if available[2]	—	
Reprints (after publication in the *Proceedings*)	1s. 3d. (includes discussion)	1s. 3d.	

[1] This charge includes a reprint of paper and discussion.
[2] If a reprint of paper and discussion is also required a remittance of 1s. 3d. should be sent.

MONOGRAPHS

Integral Control with Torque Limitation

MONOGRAPH No. 181 M

J. C. WEST, Ph.D., and M. J. SOMERVILLE, B.Sc.

The behaviour of a basic remote-position-control system with velocity-feedback stabilization and integral-of-error control is investigated, taking torque limitation of the servo motor into account. It is shown that the transient response deteriorates as the magnitude of the input signal is increased and becomes unstable above a critical value. Both phase-plane analysis and describing-function techniques are employed. The experimental behaviour to random input signals is observed. The effect of other non-linear elements added to eliminate the possibility of amplitude-dependent instability is discussed.

Some Properties of Transfer Functions of Unbalanced *RC* Networks

MONOGRAPH No. 180 R

I. CEDERBAUM

The paper describes a method of deducing some *RC*-network theorems, chiefly concerning the transfer function of an unbalanced structure from the properties of pure resistance networks. This is possible mainly because:

(*a*) the zero of the transfer function (voltage ratio) of the 3-terminal *R* network has a clear topological interpretation, namely in a zero transfer the network disintegrates into at least two parts, which may have only the reference node in common, the input and output terminals belonging to different parts.

(*b*) the expansion of the *RC*-network transfer function about the values of all its susceptances is a quotient of two polynomials in all these susceptances. The coefficients in this expansion are composed exclusively of cofactors of purely real matrices. These matrices correspond to the original network with some capacitors short-circuited and the others open-circuited.

(*c*) the vanishing of some coefficients in the numerator of the expansion of the transfer function of the 3-terminal *RC* network implies a zero of the transfer function for some *R* networks. This fact according to (*a*) imposes definite conditions upon the topology of the original *RC* network.

These limitations show that the only possible form of a degeneration of a transfer function in its non-reduced form is through the vanishing of some left or right consecutive terms of the numerator. For a generalized ladder realization of such a degenerated transfer function the discussion offers the limits of the maximum gain.

The Use of Ethylene Diamine Tartrate for Piezo-Electric Filter Elements

MONOGRAPH No. 182 R

J. BIRCH, A. G. FRITH, A. C. L. FERGUSON, R. H. A. MILES, M.A., B.Sc., and J. F. WERNER, B.Sc.

Crystal resonators suitable for use in telephone-system

channel filters have been made using ethylene diamine tartrate. Methods used in the fabrication and mounting of these units are described. The circuits for the determination of the electrical parameters are given, and the results of a large number of measurements are outlined. Freedom from unwanted resonances over the desired frequency bands has been achieved by suitable dimensioning of the plates, and by applying electrodes to only part of the crystal surface. Increased activity for crystals mounted in air can be obtained by the use of suitably placed reflectors.

Laguerre Functions: Tables and Properties

MONOGRAPH No. 183 R

J. W. HEAD, M.A., and W. PROCTOR WILSON, C.B.E., B.Sc.(Eng.)

The first twenty-one Laguerre functions have been tabulated to four decimal places (or two significant figures when this is more accurate) for values of the argument 0(0·1)1(0·2)3(0·5)6(1)14(2)40(5)100. The practical applications of these functions are briefly considered. The zeros of these Laguerre functions are also tabulated to five places, the last of which is not reliable except in the case of the smallest zero for orders above six. Differentiation and integration of Laguerre functions, orthonormal properties and addition formulae are briefly discussed. Finite or infinite series of Laguerre functions whose sums are well-known functions, such as products of polynomials and circular or exponential functions, step and delta functions, Bessel and Kelvin functions, and gamma and error functions, are stated. The general methods used for deriving some of these results are indicated.

The Polarization of Very Long Radio Waves reflected from the Ionosphere at Oblique Incidence

MONOGRAPH No. 185 R

W. C. BAIN, M.A., B.Sc., Ph.D., and C. B.-I. GLASS, B.Sc., Ph.D.

A study of some additional evidence has been made to determine the polarization of radio waves reflected from the ionosphere at a frequency of 16 kc/s over a transmission path of length 540 km. The ratio of the amplitude of vertical to horizontal electric field is found to have a mean value of 5.

Magnetic Energy and Electron Inertia in a Superconducting Sphere

MONOGRAPH No. 184

PROFESSOR E. G. CULLWICK, O.B.E., M.A., D.Sc., F.R.S.E.

The hypothesis that the magnetic energy of a current circuit is the same as the kinetic energy of the effective conduction electrons is applied to the case of a conducting sphere without resistivity in a uniform magnetic field. A surface current is induced which prevents the growth of a magnetic field within the sphere, and expressions are found for the number and velocity of effective conduction electrons which carry the current. It is found that these electrons are in radial equilibrium, moving in circular orbits under the action of magnetic forces.

The well-known Meissner effect in pure superconductors is shown to be an expected rather than an unexpected phenomenon, since its absence would require, under certain conditions, a supercurrent lacking equilibrium.

The theory is shown to lead, by means of a simple assumption, to the basic equations of the London theory of superconductivity, but with a different interpretation of the velocity parameter. Finally, the inertial supercurrent and magnetic field which should be produced by the steady rotation of a superconducting sphere, as deduced by the new theory, are shown to be exactly the same as those forecast by the London theory.

PAPERS

Electronic-Analogue-Computer Study of Synchronous-Machine Transient Stability

PAPER No. 2015 S; PART A

A. S. ALDRED, M.Sc., and P. A. DOYLE, B.E.

The paper describes a method of solution of synchronous-machine transient-stability problems by a more exact analogue representation of the system equations than has hitherto been employed. In the machine analysis emphasis is placed on the variation of field flux linkage during transient disturbances, and reasons are given why this is necessary. The equations of performance are derived in the most convenient form for analogue computing. The equivalent analogue interconnections are given both for time-varying and for constant field flux linkage. The components required for these analogues are considered briefly. The section on computer control deals with the control of integrators with reference to the introduction of 'initial conditions', 'hold' and 'compute' states. A delay unit is described which enables the switching out of a faulted transmission line to be simulated.

The results of various problems solved by the computer are presented in graphical form as boundaries between stable and unstable states. It is shown how instability subsequent to the first rotor oscillation may occur, and an explanation is proposed to account for this phenomenon.

Synchronous-machine and transmission-line analysis are presented in detail in the Appendices.

Brushless Variable-Speed Induction Motors

PAPER No. 2097 U; PART A

PROFESSOR F. C. WILLIAMS, O.B.E., D.Sc., D.Phil., F.R.S., E. R. LAITHWAITE, M.Sc., and L. S. PIGGOTT, M.Sc.

The first part of the paper describes experiments performed on a spherical machine. These experiments show that speed ranges up to 5·5 : 1 can be obtained, and that the speed range depends markedly on the ratio of pole width to pole pitch. They also show that the losses in the machine cannot be accounted for by using conventional induction-motor theory. It is shown, however, that the extra losses are due to the fact that the stator is 'short' in that it is not continuous round the machine; they are not due to the variable-speed feature.

The second part is devoted to a theoretical analysis of the properties of short-stator machines, in the first place without reference to variable-speed properties. Equations are developed which permit the formulation of the salient external characteristics of such machines, it being shown in particular that high efficiencies can be obtained provided there are four or more poles on the 'short' stator. This general theory is then applied to variable speed. The theoretical findings are supported by numerous experimental results.

Broad design criteria are laid down, but since one of these is that the machine should be large it has not yet been possible to make and test a properly designed machine.

SOME RECENT BOOKS

P. R. BARDELL

MAGNETIC MATERIALS IN THE ELECTRICAL INDUSTRY

MACDONALD. 302 PP. 32S. 6D.

This book is intended for use by senior students in physics and electrical engineering and by technical men in industry. It deals briefly with the theory of magnetism according to Ewing and Weiss and mentions the influence of crystal structure on magnetic properties. A section is devoted to permanent magnetic materials including the historical development, and this contains a useful summary of compositions and representative grades manufactured. Practical applications and methods of testing are described. Soft magnetic materials are treated at considerable length, and particular attention is paid to the twentieth-century developments on pure-iron, silicon-iron, nickel-iron and cobalt-containing alloys. Commercially available alloys are detailed with their applications and special properties.

A chapter is devoted to magnetic measurement of permeability, and of losses both under d.c. and a.c. operating conditions.

Power-frequency applications of soft magnetic materials are considered, attention being concentrated on large transformers, d.c. machines, relays, contactors, chokes and reactors. Communication-frequency applications involving soft magnetic materials include loading of telephone lines, filter-coil cores, powder and ferrite cores, nickel-iron cored transformers and C-type cores of cold-rolled silicon iron.

There is an interesting chapter on magnetic recording, in which are described the basic principles of operation and methods of studying the magnetic alloys employed. A section is devoted to the testing of materials by magnetic means and includes thickness measuring devices, flaw detection and magnetic sorting. Magnetic amplifiers and transductors are briefly described.

The author has a wide knowledge of his subject, and the book undoubtedly meets his stated intention of bridging the gap between advanced theory and practical electrical engineering applications. Since the book covers such a wide range of subject matter, in some instances the treatment is of necessity brief, but this is amply compensated for by liberal bibliographical reference contained at the end of each chapter. The book has been most carefully prepared and is a worthy contribution to the literature on this subject.

F. T. BARTHO and C. H. PIKE

FACTORY ELECTRIFICATION

MACDONALD. 398 PP. 35S.

Factory electrification ranges over a wide field, and this book covers only the principal power applications. It starts with an account of the general requirements for electrical installations, generating plant (where process-steam or water power is available), and the use of the public supply, giving details of substation and works-distribution systems. The second chapter is devoted to main-distribution switchgear, and its operational performance in association with protective systems and earthing, and the book then proceeds with the general principles and practical details of the construction, installation and maintenance of power transformers. Relative advantages of various types of cabling and wiring system and of overhead busbar for the factory network are discussed, and there are some calculations of potential difference.

There is comprehensive treatment of the induction motor and the 3-phase commutator motor, with illustrations of their construction.

The characteristics of d.c. motors and their speed-control systems, such as Ward Leonard, grid-controlled thyratrons and mercury-arc rectifiers, are compared for particular types of control. The details given of the economics of power-factor improvement by capacitors or synchronous motors, with vector diagrams and arithmetical calculations, will help many to a better understanding of this subject.

A chapter on motor control gear deals with a range of starters from the hand-operated type to drum controllers and contactor assemblies. Flexibility of different types of control and interlocking and safety requirements are featured.

Factors determining the selection of motors, after mechanical analysis of the driven machine, are stated, and consideration is given to torque, speed and current characteristics of motors for various operational purposes.

The book is well illustrated by photographs of installations. It does not, however, deal with the many individual electrical equipments that are installed in factories for a variety of processes. In spite of its title the book gives only a very limited account of the lighting of factories, and numerous essential light-current applications are not mentioned at all.

G. W. A. DUMMER

FIXED RESISTORS

PITMAN. 198 PP. 28S.

There is a constant demand for electronic components of improved performance, and it is not usually easy to obtain a clear appreciation of the worth of new designs of components that are introduced commercially. The new series of books on 'Radio and Electronic Components', to which 'Fixed Resistors' gives an excellent start, is to be welcomed for the assistance it should give design engineers and others in assessing the likely usefulness of various components. In addition, Mr. Dummer's book contains much information about resistors that is certainly useful to almost every electronic engineer.

The book has nine chapters on: general component information; general information on fixed resistors; measurements on fixed resistors; wattage, voltage and pulse ratings; general-purpose resistors; high-stability resistors; special types; experimental types; and future developments in resistor design. The chapter on measurements is particularly worth while, and many of the results of such measurements must be known before resistors can be used in precision equipment. Probably the short chapter on wattage and voltage ratings could well be expanded to stress the advantages in reliability of under-running resistors.

There are many admirable tables in the book and at its end appears a Comparison Chart of Representative Types occupying twenty-five pages, which presents technical information in a form quickly assimilable by a designer. To restrict the size of the chart the author has included the approved

Services types only. Typical commercial examples, with manufacturers' reference numbers, are given for each type, but as these individual examples usually appear to differ only in dimensions, there is some duplication of information and waste of space.

In Chapter 1, Fig. 2.1 and Table 2.1 both deal with resistive materials, but, rather surprisingly, some metals appear in one that do not appear in the other. They appear therefore to be complementary, with the table as the source of exact information, but it is unfortunate that the resistivity of copper is shown in the diagram as being significantly less than that of silver.

Long experience with high-quality wire-wound resistors wound with manganin and Eureka wires indicates that the values of the temperature coefficients given in Table 3.1 must be regarded as qualitative rather than precise since it is found that for various batches or deliveries of wire unless specifically ordered the coefficients may cover a greater range than shown. For example, manganin may be found to have a coefficient between -20 and $+100$ parts in 10^6 per degree centigrade at 20° C and Eureka may similarly vary between -20 and $+70$ parts in 10^6.

The author includes a very full bibliography, but in the preamble to this he points out that not much design information on components has been published, since it is not usually released by the manufacturers.

The book, which is addressed to users of components, can be warmly recommended to them. It is soundly designed and produced though the paper used is somewhat lacking in opacity, which has the effect of reducing the readability of some pages.

E. W. GOLDING

THE GENERATION OF ELECTRICITY BY WIND POWER

SPON. 334 PP. £2 10S.

The author of this book is well known in this country and abroad as an expert on wind power. As might be expected his book gives a detailed and easily readable account of the whole subject and stresses in particular the possible place of wind power amongst the world's other power resources. There is a good index, and a comprehensive bibliography associated with every chapter.

The book starts with a short but interesting historical section that ends with a summary of the latest developments, which surprisingly enough omits direct reference to work done in Great Britain. The next, and by far the largest, section of the book is devoted to measurement of the energy obtainable from the wind; it not only includes an account of relevant calculations but also describes in detail many of the instruments than can be used for measuring wind speed, particularly when the wind is very gusty. The author has himself played a large part in developing such instruments. This section of the book is fully documented, and illustrated with actual results which give an indication of the large effort put into the problem of measurement.

By contrast the later chapters of the book appear much more sketchy. They are concerned with the windmills themselves, but much space is taken up with describing the electrical arrangements to enable a windmill with fluctuating output to be connected to various loads. The reviewer would welcome a corresponding chapter describing the pros and cons of a windmill connected to a large Grid system, which would be the windmill's main outlet in Great Britain. The structural and aerodynamic problems of large windmills are mentioned only briefly. Flexibility of blades, pitch-changing gear and vibrational problems almost warrant a chapter to themselves.

This is perhaps not so much a criticism of the book as that far more seems to have been discovered about measuring the energy available in the wind than about solving the problems of using it. The book at any rate does what it intends to do and provides a comprehensive survey of the present state of the art.

R. L. PEEK and H. N. WAGAR

SWITCHING RELAY DESIGN

PRINCETON: VAN NOSTRAND. 486 PP. £3 10S.

Switching relays of the 'telephone' type are used to-day on a wide variety of control and supervisory equipment and the features of their design are consequently of interest to other than telecommunication engineers.

Since production of relays in this country is at the rate of several millions per annum the importance of efficient design is obvious. There was little change in the most widely manufactured types for a number of years until the wire-spring relay was produced in the United States. The Bell organization had foreseen the need for a relay better suited to modern production methods and yet capable of affording a longer fault-free life for use on subscriber trunk-dialling equipment, and in 1952 announced a design which differed appreciably from previous relays and for which considerable advantages were claimed. Two members of the development team engaged on this fundamental investigation have now written a comprehensive design manual, published in the Bell Laboratory Series of textbooks, which includes material published previously in the *Bell System Technical Journal*.

Part 1 of the book (185 pages) is a self-contained section which deals with the fundamentals of relay design by considering first the relations governing the performance of relay magnets and associated contact-spring assemblies, and then the practical application to the problem of an economic relay design. For most students this section should to a large extent cover their examination requirements.

Part 2 (279 pages) is devoted to an analysis of the magnetic and mechanical problems in the design of the electromagnetic and contact-spring systems of relays and includes an extensive mathematical treatment. Analytical procedures for evaluating the characteristics of relays are employed to determine the design conditions for optimum performance, and a full treatment is included of the energy relations of magnetic circuit to mechanical output and of the deflection and vibratory characteristics of spring systems.

The literature on relay design has hitherto been mainly spread throughout articles in technical journals and the valuable information now assembled under a single cover will be welcomed by the professional worker in this field. Since the book is very likely to become a standard reference work it is a pity that some matters of particular interest have not been more fully dealt with. For example, the choice of contact materials and the subject of contact erosion receive but scant treatment, which is disappointing, particularly in view of the existing differences between American and British practice. Similarly the characteristics of magnetic materials used in relay construction could with advantage have been dealt with more fully in view of their fundamental importance. The coverage of the book does not extend to descriptions of such specialized relays as the reed or the electrostrictive types, nor does it adequately cover polarized relays. Despite these limitations the book can be thoroughly recommended.

LIBRARY ACCESSIONS

**Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members.*

BOOKS

HIRST, A. W. 621.31

Applied Electricity*

3rd ed. London, Blackie, 1956. pp. xxx, 398. 22 × 15 cm. 25s.

Written for the syllabus of Part I of the London B.Sc.(Eng.) examination and appropriate for The Institution's examination. Contains many examples, both worked and not worked, from recent papers, but it may be found useful also as a reference work. Rationalized M.K.S. units are used in the present edition.

HODGMAN, C. D., and OTHERS (Editors) 53(083)

Handbook of Chemistry and Physics. A ready-reference book of chemical and physical data

37th ed. Cleveland, Ohio, Chemical Rubber Publishing Co., 1955. pp. 3156. 18 × 12 cm. £5.

HUBERT, C. I. 621.313.004

Preventive Maintenance of Electrical Equipment. Preventive programs, trouble shooting, emergency repairs, and operating techniques

New York, McGraw-Hill, 1955. pp. x, 214. 24 × 16 cm. 30s.

Deals with motors and generators.

JONES, G. O., and OTHERS 539

Atoms and the Universe. An account of modern views on the structure of matter and the universe*

London, Eyre & Spottiswoode, 1956. pp. 254. 22 × 14 cm. 25s.

Describes for the general reader the fundamental particles of matter—protons, neutrons and electrons, explaining the phenomena associated with them such as radioactivity, nuclear disintegration, fission and fusion. The developments of nuclear energy for military and peaceful purposes are explained. Cosmic radiation, modern theories of the properties of matter, quantum theory and relativity are discussed.

JOUGUET, M. 537

Traité d'Électricité Théorique. Tome II. Électrocinétique et magnétostatique

Paris, Gauthier-Villars, 1955. pp. viii, 316. 24 × 16 cm. £4 16s. approx.

Theoretical electricity—Electrokinetics and magnetostatics. Vol. I deals with electrostatics.

KEMP, P., and DATE, W. H. 621.313.3

A.C. Generators and Motors

London, Pitman, 1956. pp. vii, 51. 18 × 13 cm. 6s. 6d.

Reprinted from 'Electrical Wiring and Contracting' (New Era Publishing Co.) Gives a brief introduction to the construction and characteristics of a.c. machines. Suitable for students working for City and Guilds, or National Certificates.

KING, R. W. P. 621.392

Transmission-line Theory*

New York, McGraw-Hill, 1955. pp. xii, 509. 24 × 16 cm. £4 10s.

A rigorous treatment of high-frequency lines and limited to steady-state problems. Considers electromagnetic principles rather than equivalent networks.

LEE, R. 621.314.2

Electronic Transformers and Circuits*

2nd ed. New York, Wiley; London, Chapman and Hall, 1955. pp. xvi, 360. 23 × 15 cm. £3.

This edition contains a new chapter on magnetic amplifiers and one on pulse circuits.

LO, A. W., and OTHERS 621.314.7

Transistor Electronics*

Englewood Cliffs, New Jersey, Prentice-Hall, 1955. pp. xii, 521. 22 × 15 cm. £4 16s.

Discusses the physical theory of transistors and their characteristics, parameters and equivalent circuits. Then describes the use of transistors in amplifiers, oscillators, modulators and pulse circuits.

LOCKE, A. S., and OTHERS 621.396.9

Guidance*

Princeton, New Jersey, Van Nostrand, 1955. pp. xvii, 729. £4 10s.

The development of guided missiles involves studies and research in a number of widely different fields, all of which are discussed in this book. Of particular interest to electrical engineers are the chapters on radio transmission and communication, radar, servo systems, and telemetering. The treatment throughout is largely mathematical.

MANCHESTER JOINT RESEARCH COUNCIL 001.8

Industry and Science*

Manchester, University Press, 1954. pp. viii, 188. 22 × 14 cm. 12s. 6d.

A report of an investigation carried out in the Manchester area. It discusses the influence of the employment in industry of scientists and technologists. Describes the extent to which research and development is carried out within industrial firms, the use of research associations, contacts with the universities, and other sources of information.

MARTON, L. (Editor) 621.38

Advances in Electronics and Electron Physics. Vol 7.*

New York, Academic Press, 1955. pp. x, 527. 24 × 16 cm. £4 12s.

This volume contains chapters on the physics of semi-conductor materials, the theory of the electrical properties of germanium and silicon, energy losses of electrons in solids, sputtering by ion bombardment, radio astronomy, analogue computers, and energy discharges in gases and modern electronics.

MINER, D. F., and SEASTONE, J. B. (Editors) 62.002.3

Handbook of Engineering Materials

New York, Wiley; London, Chapman and Hall, 1955. pp. xi, 1093. 22 × 15 cm. £7.

Presents sufficient data to be a useful guide to the selection of a wide range of materials, and suggests sources for more complete information. The general information includes specification curves and mathematical data on sampling statistics and mathematical and physical tables.

NOWAK, A., and SCHILLING, F. 621.396.619

Die Empfangstechnik Frequenzmodulierter Sendungen (Reception techniques for frequency-modulated transmissions)*

Hanover, Siegfried Schütz, 1955. pp. 290. 22 × 15 cm. 32s. approx.

Discusses f.m. transmission and the circuits of f.m. receivers.

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 25TH MAY, 1956

	No. of Contributors	£	s.	d.
£1 000 and over	6	6 000	0	0
£100 to <£1 000	29	6 386	3	0
£5 to <£100	783	8 533	6	5
£2 to <£5	1 907	5 261	2	2
Under £2	19 539	10 254	19	0
	22 264	£36 435	10	7

APPOINTMENTS AND NOMINATIONS

BRITISH STANDARDS INSTITUTION TECHNICAL COMMITTEES

Committee on Electrical Accessories (ELE/4)

The Council have nominated Mr. S. L. M. Barlow, ASSOCIATE MEMBER, to serve as their representative on the above Committee in place of Mr. P. V. Hunter, C.B.E., HONORARY MEMBER.

Proposed Panel: International Vocabulary of the I.E.C.—Group 25—Distribution of Energy (ELE/9/10/25)

The Council have nominated Mr. T. G. N. Haldane, M.A., PAST-PRESIDENT (with Mr. R. S. Orchard, M.A., MEMBER, as his deputy), to serve as their representative on the above Panel.

B.S.I. Working Party for Commonwealth Conference on Electric Cables (ELE/3/–/2)

The Council have nominated Mr. P. V. Hunter, C.B.E., HONORARY MEMBER, to serve as their representative on the above Working Party in a permanent capacity.

Sub-Committee on Mineral-Insulated Cables (ELE/3/18)

The Council have nominated Mr. G. Auterson, B.SC., ASSOCIATE MEMBER, and Mr. J. S. McCulloch, ASSOCIATE, to serve as their representatives on the above Sub-Committee.

Committee on High-Tension and Low-Tension Cables for Aircraft (ACE/6)

The Council have nominated Mr. D. B. McKenzie, B.SC., MEMBER, to serve as their representative on the above Committee in place of Mr. A. N. Irens, MEMBER.

Committee on Telecommunication Measuring Instruments and Test Equipment (TLE/8)

The Council have nominated Mr. E. D. Hart, M.A., ASSOCIATE MEMBER, to serve as their representative on the above Committee.

COMMITTEE ON THE APPLICATION OF ELECTRICITY TO INDUSTRIAL PROCESS HEATING

On the nomination of the Central Electricity Authority, the Council have appointed Mr. V. A. H. Clements, MEMBER, to serve on the above Committee in place of Mr. W. B. Noddings, M.ENG., MEMBER.

WANDSWORTH TECHNICAL COLLEGE

The Council have nominated Mr. D. W. Hopkin, MEMBER, to serve as their representative at this college in place of Mr. T. E. Goldup, C.B.E., VICE-PRESIDENT.

REGIONAL ADVISORY COUNCIL FOR THE ORGANIZATION OF FURTHER EDUCATION IN THE EAST MIDLANDS: ADVISORY PANEL FOR THE ENGINEERING INDUSTRY

The Council have nominated Major H. E. Knight, MEMBER, to serve as their representative on the above Panel.

RETIRED MEMBERS AND THOSE OF LONG STANDING

Members are reminded of a rule which has been in existence for some years and which enables Corporate Members and Associates who have retired from the profession and are still desirous of retaining their membership of The Institution to do so without payment of further subscriptions. It is left to the members concerned to make application to be brought within the rule. The rule, which does not apply retrospectively, is as follows:

Any Corporate Member or Associate who has reached the age of 60 and has retired from the practice of his profession or business may apply to the Council to waive his future annual subscriptions provided that his membership of The Institution has been continuous for at least 25 years. If he desires to continue to receive the *Journal* he can do so on payment of 10s. per annum. Parts A, B and C of the *Proceedings* will also be available to him at the appropriate subscription rates.

In addition to the foregoing, it should be noted that a further rule provides that as soon as a member of any class has completed 50 years of membership he will cease to be asked to pay any further membership subscriptions, regardless of whether he is still in remunerative employment. The rule operates automatically, and the member on qualifying is notified accordingly. If he desires to receive the *Journal* or the *Proceedings* the arrangement for retired members of 25 years' standing also applies.

C.C.I.F. PUBLICATIONS

The International Telephone Consultative Committee (C.C.I.F.) are publishing a series of green books summarizing the work of the Committee from 1951 to 1955. These will replace the yellow books previously issued. There are six volumes, published in both French and English, dealing with such topics as the minutes of the 17th Plenary Assembly of the C.C.I.F., the protection and maintenance of telephone lines, the measurement of performance rating, signalling and switching, and tariffs. The prices of the volumes vary from 7.80 to 40 Swiss francs (13s. to 66s. approx.), the price for the whole set being about 137 Swiss francs. These publications may be obtained from the Publications Department of the International Telecommunications Union, Palais Wilson, Geneva.

DEFERMENT OF CALL-UP

The Ministry of Labour and National Service have issued revised instructions to National Service Deferment Boards affecting men who have completed a full-time course of study and have obtained a university degree in chemical engineering, physics or general science with physics as one of the subjects.

These graduates may now be allowed further deferment, not exceeding two years, to undergo a graduate apprenticeship in electrical engineering and to complete the necessary studies to qualify for Graduate Membership of The Institution, provided that they proceed straight from the university and can complete their training and further studies before passing out of liability for National Service. It will be necessary for such candidates to attend courses approved by the Council and to produce a certificate from The Institution that the full educational requirements for Graduate Membership can be satisfied within two years.

JOINT CONFERENCE ON FATIGUE OF METALS

The Institution of Mechanical Engineers is arranging, in conjunction with the American Society of Mechanical Engineers, a joint conference on the fatigue of metals. This will be held in two parts, the first in London from the 10th to 14th September, 1956, and the second in New York from the 28th to 30th November, 1956. The London meeting will contain ten sessions, the first and last of which will be held in the Central Hall, Westminster, and the remainder at The Institution of Mechanical Engineers. Owing to the large number of papers authors will not be able to present their papers in person, and abstracts will be read by reporters, allowing two hours during each session for discussion and replies. Advance copies of all the papers will be available, and the same papers will be presented in both Britain and the United States.

Members who wish to register may obtain application forms from the Secretary, The Institution of Electrical Engineers, Savoy Place, London, W.C.2. Further details of the Conference are available from the Secretary, The Institution of Mechanical Engineers, 1 Birdcage Walk, S.W.1.

STUDENTS' QUARTERLY JOURNAL

The June issue of the *Students' Quarterly Journal* contains, for the first time, a colour supplement, illustrating a recent student paper on 'Colour Television'. In addition to papers dealing with a variety of technical subjects, from high-voltage circuit-breakers and computers to electronics for chemical analysis, there is a description by a former member of the London Section committee, now in Canada, of her 3 000-mile drive from Detroit to Los Angeles. Correspondence, book reviews and reports on Section activities are also given.

VACANCY ON THE INSTITUTION STAFF

Applications are invited for the post of Senior Technical Officer in the Education Department. The successful candidate will be required to share in the work of the department, in particular to take a leading part, under the direction of the Education Officer, in the technical aspects of the work and to deputize for that officer when necessary. He will also be required to serve as secretary to committees dealing with branches of The Institution's education, training and examinations work, and to assist in the preparation of reports. Applicants should preferably be between the ages of 28 and 35 and should be graduates in engineering or science with experience in industry or technical education. The salary will depend on age, qualifications and experience. Entry to a superannuation scheme would follow a short period of service. Those who are interested should write to the Secretary, The Institution of Electrical Engineers, Savoy Place, London, W.C.2, giving full particulars of their education, training and experience.

AN INSTITUTION TIE

It was the London Graduate and Student Section Committee who first put forward the suggestion that there should be an Institution tie. This proposal was eventually embodied in a report prepared last year by a Committee which had been set up by the Council to consider the subject of Student Membership.

After the Council's acceptance of the proposal for a tie, a Sub-Committee, representative of all classes of membership, was appointed to consider the designs which had been prepared by three specialists in this field. The Sub-Committee after much discussion selected the design shown in the illustration.

Supplies of the tie, and a square (30″ × 30″) of the same design, are now available on application to the Secretary. The respective charges are as follows:

Ties:			
silk	£1	1s.	0d.
rayon-silk		15s.	0d.
Squares:			
silk	£2	12s.	6d.
rayon-silk	£1	15s.	0d.

The general appearance of the tie may be seen from the accompanying illustration. A wavy gold line, edged in red, running diagonally across the navy-blue background of the tie represents wave motion, one of the fundamental concepts of electrical engineering which appear on the Institution's coat of arms. A shield of light blue—by common consent the predominantly 'electrical' colour—shows a winged golden thunderbolt enclosed in a golden ring bearing golden fleurs-de-lis at the four cardinal points. This alludes to the power of electricity circumscribed and under control; the fleurs-de-lis on the encircling ring make a passing reference to the compass card and thus to our well-known seal and to the work of Kelvin.

Members may like to be reminded that a description of the complete coat of arms together with a colour reproduction in large quarto size may be obtained on application to the Secretary, price 2s.

Elections and Transfers

The following elections and transfers approved by the Council are effective from the 26th April, 1956.

ELECTIONS

Graduates

ALEXANDER, James William Francis.
ARMSTRONG, Peter Frederick, B.SC.
AUSTIN, Dennis.
BADEN-FULLER, Arthur John, B.A.
BARBOUR, James.
BATCH, Bertie Alfred, B.SC.(ENG.).
BIRD, Gordon Gerald.
BISHOP, John Reginald.
BRYAN, David Gerald.
BUSTON, Russell.
CADWALLENDER, George Henry.
CAWSEY, Raymond Alfred.
CHITTENDEN, Stephen.
CHIVERS, Edgar Leslie.
CHUE, Wun Lin.
COTTON, Alan Robert, B.SC.(ENG.).
CREBER, David John.
CRESSALL, Peter Alan Gordon.
CROXTON, Gordon Frank.
DAVIS, Stanley Charles.
DITCHBURN, John Robert.
DOLLERY, Alan Albert.
DUFFIELD, Denis Reginald, B.SC. (ENG.).
ETMAN, Mohamed Hamed, B.SC. (ENG.).
FREEMAN, Ernest Allan, B.SC.
GARDNER, Dennis William Ernest.
GATENBY, Donald, B.SC.(ENG.).
GOODIER, John Scanlan.
HODGKISS, James Robert.
HOLBORN, John Colin.
HORTON, Frank Bertram.
HORWOOD, Sidney Alan.
JACOBS, Derek Arthur, B.SC.(ENG.).
JOHNSTON, Arnold Robert, B.SC., PH.D.
JONES, Matthew Brown.
KANITKAR, Sharad Govind.
LAVENDER, Charles Edwin.
LBQUAY, Aldwyn Lambert, B.SC. (ENG.).
LEWIN, Desmond Paul.
LORIMER, John Alfred.
McCOSH, Andrew Kirkwood, B.A.
McDONNELL, Patrick, B.SC.
McPHUN, Michael Keith.
MARCHANT, Stanley Ernest.
MARSDEN, Brian Francis.
MAUNSELL, Henry Ian Geoffrey, B.SC.(ENG.).
MAYNE, David Quin, B.SC.(ENG.).
MAYO, Frederick Adolphus Roland.
MINTO, Alan Malcolm Greenfield, B.SC.(ENG.).
MITCHELL, Sub-Lt. David Gordon, B.SC.(ENG.), R.N.V.R.
MORRIS, John.
NIKIFORUK, Peter, B.SC., PH.D.
OLIVER, Keith.
PENDLEBURY, Stephen Austin.
PICTON-ROBINSON, Neil.
PINTO, Derek Oswald.
PRATT, Stuart William.
PUZEY, Tom Reginald.
REICHARD, Stefan Roman.
ROACH, John Andrew.
ROSENBAUM, Harold.
ROZNER, Felix, B.SC.(ENG.).
SAMPSON, William Alan, B.E.
SEXTON, Michael Cornelius, M.SC.
SISSONS, James Bernard.
SMITH, John Joseph.
STEEL, Colin Edward.
SULLIVAN, Gilbert Ronald.
SZUMSKI, Henryk.
THOMS, Alan.
TRUSCOTT, Derek Alan.
TYLER, John.
VINCENT, James Arthur, B.ENG.
WAGGETT, John Edward Bernard.
WATERS, James.
WEST, Edward George.
WHITAKER, Alan Ernest.
WHITTEN, Donald.
WICKER, Ivan Geoffrey.
WILLIAMS, Alan, B.SC.
WILLIAMS, Anthony.
WYMAN, Sub-Lt. Patrick Roy, B.SC. (ENG.), R.N.V.R.

Students

ANDERSON, Dennis.
AULT, Maurice Peter.
BAINES, Patrick.
BAKER, Roy Dixon.
BEARDSMORE, William.
BEATTIE, Robert.
BECK, Barrie James.
BELL, Gerald William.
BRISTOW, John.
BURFITT, Robert Edgar.
BURROWES, Nicholas Edmund.
CALLENDAR, Michael Hugh.
CAMPBELL, Robert Clarke.
CHRISMAS, James Frank.
CLAY, Michael Charles.
COHEN, Allan.
CONNOLLY, Nicholas Thomas.
CULLIMORE, Geoffrey Richard.
DAVIDSON, William.
DE SILVA, Arumakankanange Sumithra Malinga.
DOOLAN, Patrick Thomas.

Students (contd.)

DUDHIA, Champak Laxmanbhai.
DUFFY, Rodney Michael.
ELCOME, John.
ELLEN, John Edward.
FRENCH, Michael Hutt.
GILBERT, John Barrie.
GILES, George Roland.
HARRIS, Michael Lile.
HILL, John Anthony.
HJERTHOLM, Arne Bertel.
HOLLIDAY, Michael John.
HOUNSOME, Graham John.
HUBBARD, Jack Edward.
HUDSON, Richard Mervyn.
HUMPHREYS, Geoffrey Edward.
HUTCHINS, Roy.
INGHAM, Jeremy Colin.
JACKSON, Bryan Keith.
JAMES, Edward Clifford.
JESSANI, Mohan Choithram.
JORDENS, Henry Edward.
KERMAN, Francis Edward.
KIDD, David Alan.
KNOWLES, Joseph.
LANGFORD, John Alaistair.
LOWE, George Hsien Tsou.
LUCAS, David Alan.
McCONNELL, Bryan.
McDONNELL, Francis Anthony.
McPHADEN, Stewart Norman.
MICHIGAN, Malcolm William Noel.
MILLAR, Charles George Declan.
MITCHELL, Keith.
MORTIMER, William Raymond.
NAGY, Andrew Francis.
NASH, Pilot-Officer Leslie Albert, R.A.F.
NICHOLLS, Henry Brian, B.SC.
NIGHTINGALE, Clive Richard.
O'CONNOR, Edward James.
OGBORN, Raymond Henry.
PAYNE, David John.
PERRY, Geoffrey Samuel.
PETTERSON, Odvar.
PHILLIPS, John Arnaud.
PHILLIPS, John Leslie.
POOLE, David Albert Joseph.
POOLE, Raymond William.
PRICE, Peter Richard.
PROSSER, Graham Henry Pryce, B.SC.
ROSE, Michael John.
SAMPSON, Edward Arthur.
SMITH, Peter Howard.
SPENNING, Jan Herman.
STOREY, David William.
SYNNOTT, Edward Christopher, B.E.
THIRUCHELVAM, Arulaih Sinnayah.
VASWANI, Peter Kishinchand Tolaram.
VICKERS, Peter James.
WALKER, David Newman, B.SC.
WALKER, James Martin.
WALTON, James William.
WEAVER, Graham George.
WICKS, Anthony John.
WILLIAMS, Peter Emrys.
WINSTANLEY, Harry.
WRIGHT, Michael Ronald.
WYBORN, Gregory Leon.
YOULE, Eric.

TRANSFERS

Student to Graduate

ADLER, Eric Leon, B.SC.(ENG.).
BAILEY, Philip.
BASSANO, Michael John, B.SC.(ENG.).
BATTYE, Roy.
BAXTER, Barry Thomas.
BLAKE, Richard Levi.
CARR, William Alan Cruswell, B.SC.TECH.
CHIVERTON, Malcolm Campbell.
COLE, David Arthur.
CONSTANTINE, Bernard, B.ENG.
COOKE, Martin Eric.
COOPER, Brian James.
CRAWFORD, Charles Ian.
CURTIS, Gordon Frank, B.SC.(ENG.).
FLEWKER, George, B.SC.
GEIS, George Julian.
GREEN, John Uvedale.
GUPTA, Mukul, M.SC.
HALL, John Keith, B.SC.(ENG.).
HANCOCK, John Gordon, B.SC. (ENG.).
HARDING, Derrick Desmond.
HAYNES, Joseph William, B.SC.
HELICON, Thomas Osborne, B.SC. TECH.
HOLLAND, Anthony John.
HULLEY, Fl.-Officer Lancelot Norman, B.SC., R.A.F.
KHAMBANONDA, Archomphon, B.SC.(ENG.).
KUMAR, Aruni, B.SC.(ENG.).
LAMB, Laurence James.
LAWEE, Hayim Shoua, M.SC.
LAWRIE, William Skinner.
McCLELLAN, John Kearton.
McKAY, John, B.SC.
McKELVIE, Ian James.
MILLER, John Ernest, B.SC.(ENG.).
RUSTOMJEE, Jamshed Burjor.
SINGH, Sub-Lt. Shri Bansh Narayan, B.SC., I.N.
SMITH, John Harvey.
SMITH, John Kenneth, B.SC.(ENG.).
SUKUL, Sub-Lt. Jagat Narayan, B.SC., I.N.
THOMPSON, Daniel Crerar, B.SC.
UNDERY, Denis William.
WARDEN, Roland Robert.
WILLIAMSON, David Anthony, B.SC.(ENG.).
WILLIS, Kenneth James.
WILSON, John Fergus Graham.
ZEMENIDES, Axendis Dimitri.

Forthcoming Events

JUNE

21 *Thursday* — Institution Conversazione at the Royal Festival Hall

25 *Monday to* 29 *Friday* — Summer Meeting in the Midlands

SEPTEMBER

6 *Thursday to* 9 *Sunday* — Supply Section Visit to Northern Ireland

British Nuclear Energy Conference: Forthcoming Programme

JULY

3 *Tuesday to* **6** *Friday* — A Conference on the Physics of Nuclear Reactors, sponsored by The Institute of Physics. For full particulars, see April *Journal*, p. 263.

NOVEMBER

22 *Thursday and* **23** *Friday* — A Symposium of 20 papers on the Calder Hall Nuclear Power Plant, some details of which were given in the May *Journal*, p. 317. The Symposium will be held at The Institution of Civil Engineers, Great George Street, London, S.W.1. Advance copies of the papers will be available at the beginning of November to members who wish to attend the meetings. The papers and discussions will be published in *The Journal of the British Nuclear Energy Conference*. A registration fee of £1 will be charged towards the cost of the advance copies. All those wishing to attend are requested to obtain an application form from the Secretary, British Nuclear Energy Conference, 1–7, Great George Street, London, S.W.1.

Contents of the Current Issues of the *Proceedings*

DATE OF JOURNAL REVIEW OR SPECIAL ARTICLE

PART A. POWER ENGINEERING (JUNE 1956)

Scottish Centre: Chairman's Address

T. LAWRIE, C.B.E., F.R.S.E., M.A.

June 1956 — **Highland Water Power—The Developments of the North of Scotland Hydro-Electric Board** (PAPER No. 1909 S, SEPTEMBER 1955)

J. W. GRIEVE, B.SC.

June 1956 — **Electric Traction** (*A Review of Progress*) (PAPER No. 2074)

C. H. FLURSCHEIM, B.A.

June 1956 — **Switchgear** (*A Review of Progress*) (PAPER No. 2012)

P. BAXTER

March 1956 — **A New Meter for the Kilovolt-Ampere Demand Charge** (PAPER No. 1927 M, NOVEMBER 1955)

L. GOSLAND, B.SC.

April 1956 — **Age and the Incidence of Fires in Electrical Installations** (PAPER No. 1938 U, JANUARY 1956)

T. H. BARTON, PH.D., O. I. BUTLER, M.SC., AND H. STERLING

April 1956 — **The Theory and Characteristics of the 3 : 1 Pole-Changing Induction Motor** (PAPER No. 1951 U, DECEMBER 1955)

T. H. BARTON, PH.D., O. I. BUTLER, M.SC., AND H. STERLING

April 1956 — **Applications of the 3 : 1 Pole-Changing Motor** (PAPER No. 2010 U, FEBRUARY 1956)

PROFESSOR G. H. RAWCLIFFE, M.A., D.SC., AND B. V. JAYAWANT, B.ENG.

April 1956 — **The Development of a New 3 : 1 Pole-Changing Motor** (PAPER No. 1958 U, DECEMBER 1955)

Discussion on **The Application of Symmetrical Components to the Measurement of Phase Difference in Single-Phase Circuits** before the Western Centre

GEOFFREY F. KENNEDY, M.A., AND F. J. HUTCHINSON, M.ENG.

Power Station Auxiliary Plant (ABSTRACT No. 2114)

Discussion on **Aluminium-Sheathed Cables** before the North-Eastern Centre, the Mersey and North Wales Centre, the North-Western Centre, the North Staffordshire Sub-Centre, the Southern Centre, the Western Centre, the South Midland Supply and Utilization Group and the South-Western Sub-Centre

Discussion on **A Criterion of Distribution Cost** before the North-Eastern Centre

Discussion on **Proving the Performance of Circuit-Breakers, with particular reference to those of Large Breaking Capacity** and **A New Testing Station for High-Power Circuit-Breakers** before the North Staffordshire Sub-Centre, the South Midland Supply and Utilization Group, and the Northern Ireland Centre

PART B. RADIO AND ELECTRONIC ENGINEERING (MAY 1956)

See *Journal*, May 1956, page 318.

PART C. MONOGRAPHS (MARCH 1956)

See *Journal*, March 1956, page 206.